Coordination Chemistry
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Lecture - 5
Ligands-III and Nomenclature-I

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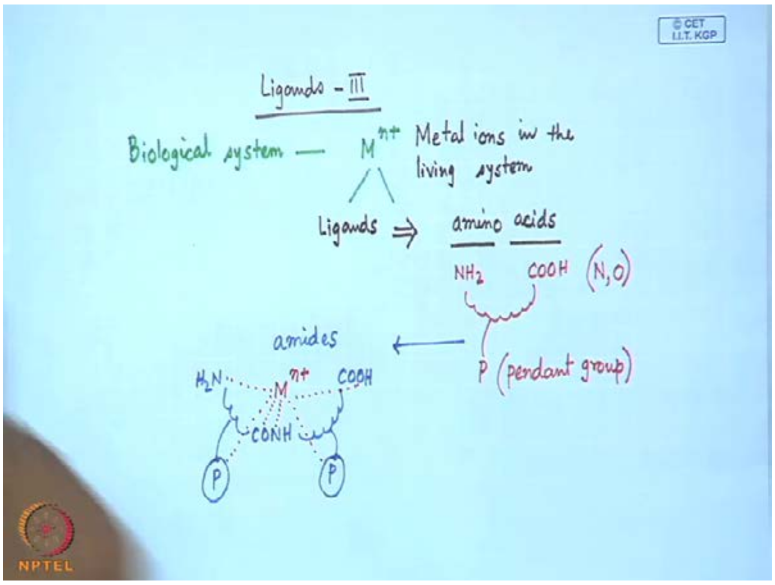

Good evening everybody. So, today we will finish the remaining part of the ligands, how we are classifying; so, it is part three; so, the different classification what we have seen. Now, we will just talk about one of the important class what we find in the Biology. So, if we deal with some biological systems, so well, we are talking about so much about the different metal ions. So, these are the metal ions, corresponding metal ions in the living system. So, if we can have metal ions in the living system, then obviously we can have the corresponding ligands.

So, what are those ligands that typically bind the metal ions, which are available in the biological system? And, most important class of ligands will… all the time we will be talking about that, if we have the corresponding amino acids and all the amino acids has the name stands, they have all the time the corresponding amino function and the carboxyl function. And, we will all know that if we have certain species, the N H 2 function as well as COOH function, and if both the groups are participating to bind the metal ion, we will basically get a ligand system which can be considered as a no donor ligand.

And, apart from that this is the corresponding amino acid sequence. If you can have the long chain which is connected within this N H 2 and C OO H function, then we can have some pendant groups as well, which is the corresponding pendant group. So, if these basic amino acids as well as their condense products; that means amides are there. So apart from this; that means we have the N H 2 functionality. Then, we can have the peptide back bone and the other C O O H and we can have these pendant group P from here as well as pendant group from here, depending upon the corresponding availability of the amino acid sequence in the long poly peptide chain.

So, we will find that if this particular system can have some interaction with the metal ion, then these N H 2 group can start interacting these pendant group with some nitrogen hetero cycle or the carboxin can also give some interaction with metal center. The N H function of the amide group as well as the oxygen function of the amide group can also show some interactions. Similarly, the other P group as well as one of these oxygen of the carboxin can show some interaction with the metal ion. So strictly speaking, any biological system containing amino acid or amide or polypeptide can have some potential binding donor groups which can bind the metal ions very nicely.

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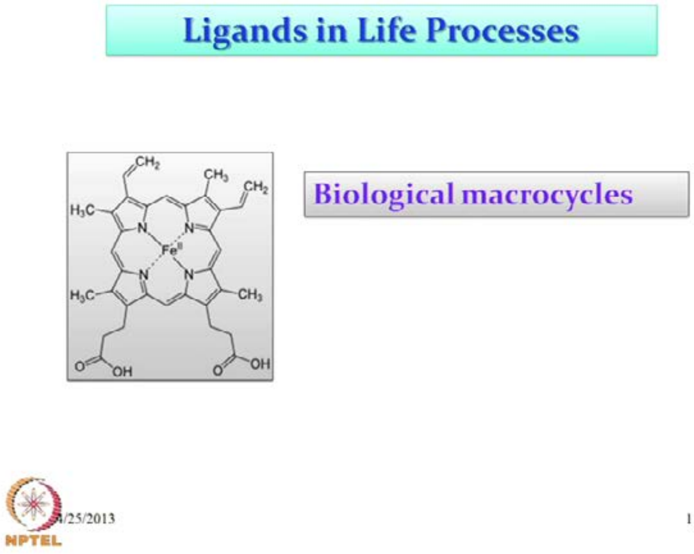
Ligands in Life Processes

Biological macrocycles

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So, we will see that what are the different types of ligands we can have in the life processes. Very basic life processes are all dependent on the metal ions and also they are dependent very much on the corresponding ligand system. Since, in this class we are talking about the corresponding different types of ligands what we can have and their corresponding availability to the metal center which are available in life system in a very low concentration. So, the most important class of this, apart from this amino acid and polypeptides, we can have the biological macrocycles. And, this biological macro cycles can have of different types. One is of this type which is basically a cyclic ligand where four nitrogen donor atoms are available. And, all four nitrogen donor atoms are connected within a big macrocyclic structure and the metal ion will be sitting at the center of this cycle.

So, this particular… that the cyclic rain is the pyrole ring, we all know. So, this pyrole ring when they are connected by some methyne regions, the C H bridge; these are all four C H bridges. So, when four pyrole units are connected by four methane rings, we get the corresponding macro cycle. And, this macro cycle is known as the corresponding tetrapyrole macrocycle.

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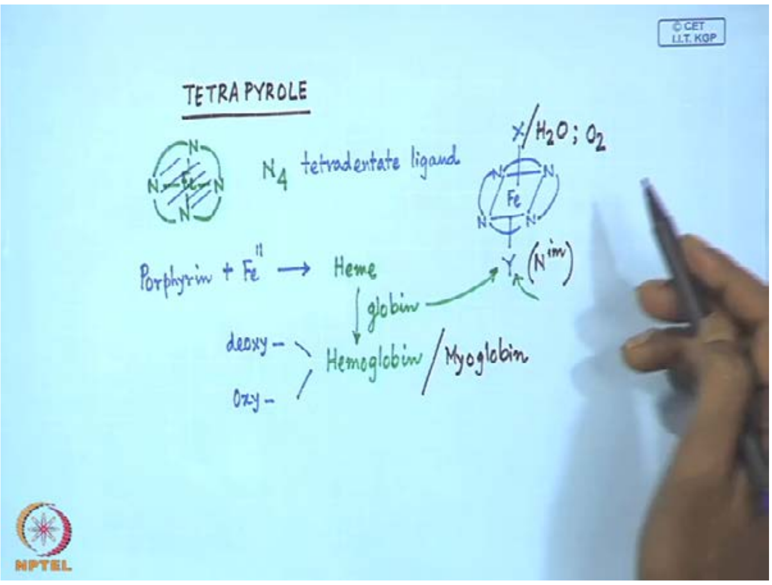

So, biological system can have a tetrapyrole system, which is a tetrapyrole system. So, we can have one pyrole unit, another pyrole unit, another pyrole unit and the fourth one. So knowing that thing that, what we have seen the… triethylenetetraammine and so many types of ligands we have discussed so far, this immediately tells us that, if all the four nitrogen donor atoms are utilized for metal coordination, we get a typically N 4 tetradentate ligand system. So, this N 4 tetradentate ligand system is suitably binding to the metal system in a planar arrangement.

If this particular structure is planar one, so for any octahedral type of binding, which is a three dimensional binding, we can have nitrogen, nitrogen, nitrogen and nitrogen over here. So, all four nitrogen atoms if they are connected, we get at a tetrapyrole unit. And, if there is further coordination from the fifth coordination site and the sixth coordination site like two donor groups like X and Y, we get a typical octahedral coordination around the metal center.

If the metal center what we are just seeing in the slide, that iron is there, so if we consider that iron is present; so, we can have a typical octahedrally coordinated center, where only one ligand system is present which is providing the N 4 tetradentate coordination. And, two monodentate coordination are coming which are in apical direction. One is perpendicular above the plane and another is below the plane, which are X and Y; so, giving a typical six coordinated geometry around this iron center.

So, what we see that this particular iron, when we can have a large heterocyclic organic ring we call this as the porphyrin. So, porphyrin is the unit which is present and since it has biological origin, so the biologically this can be synthesized in our body also, in the human body also, we can synthesize this particular unit from some amino acid residues. And, these amino acids residues ultimately can give us some substituted positions.

So, we can have this pyrole unit, these two positions; so, all four pyrole unit can have two positions for regular substitutions. And, all eight positions are suitably substituted. So, after substitution we get basically a one type of porphyrin ring. And, that particular porphyrin ring present is in one system and functioning for one particular reaction. And, if we vary the substitutions and instead of this methyl and phenyl groups if we can have some other groups, these are the two propionic acid groups. And, these two are again methyl substitutions. So, if we just simply vary from all these positions, so substitutions can change the nature of the porphyrin and we get the corresponding porphyrin as porphyrin a porphyrin b and all these different types of nomenclature also we can make.

So, we can have the basic porphyrin. And then, the suitable substitutions on that particular porphyrin can give rise to a system, where we can have the corresponding different types of the reactivities for their biological origin. So, when we have the simple porphyrin and which is bound to F e 2, that means iron two; so in this plane typically what we get, within this particular plane we have, if we have iron and when it is bound to this all four positions, we get the heme group. So, depending upon the nature of this porphyrin we consider as heme a, heme b, heme c and all these. But, the basic thing is that we have the porphyrin plus iron giving rise to the heme structure. And, when the protein chain is coming which is globin, and this particular globin is responsible for this coordination from this Y.

So, the globin is basically responsible for coordination from Y; we get hemoglobin, which is present in our blood. And, hemoglobin is the molecule which is responsible for our oxygen trapping reaction. So, there are not only hemoglobin, but also we can have the myoglobin molecules. And, they are all typically iron tips of a pyrole system. So, iron complex of the porphyrin ligand. So, iron complex of the porphyrin ligand further coordinating form the globin, so is the methyl zone nitrogen is formed, the amino acids site chain is coming. So, this is nothing but the nitrogen of the amide zone ring of the long polypeptide chain of the globin which is bound from Y. And, this particular X is responsible for binding water molecule or the oxygen, when we are utilizing hemoglobin for respiration.

So, when we have the hemoglobin form or the myoglobin form, we can have two different types of hemoglobin. One is the corresponding deoxy form; that means, when it is not interacting with the dioxygen, it is only coordinating to the water from the sixth site. And, another form is known as the oxy form; when this water molecule from this position is replaced by dioxygen molecule. So, during respiration we need oxygen. And, that oxygen is stored in our body and ultimately is required for burning of the food material for our energy and for A T P synthesis. But, that starts from the very basic Coordination Chemistry of iron bound by the porphyrin ring and the globin chain. So, all the five positions are occupied. So, only available position is the sixth site. And through that sixth site, it is only interacting with the dioxygen molecule giving interesting reactions related to the oxidation of food molecules.

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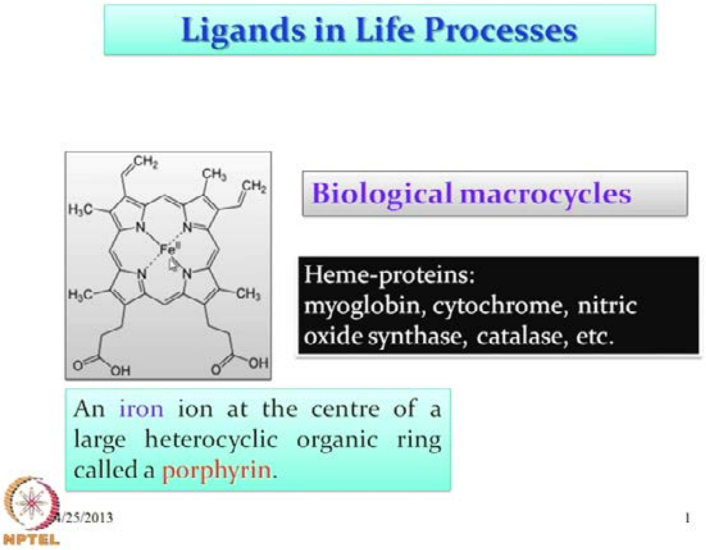

Ligands in Life Processes

Biological macrocycles

Heme-proteins:
myoglobin, cytochrome, nitric oxide synthase, catalase, etc.

An iron ion at the centre of a large heterocyclic organic ring called a porphyrin.

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So, not only this hemoglobin which is present in our blood, but there are several other molecules are known as heme-proteins. So, when we just consider these as the typical heme-proteins, we can immediately say that one particular thing can be myoglobin, then hemoglobin which are present in red blood cells, then also we need cytochromes which are present in electron transfer chain. But, there also iron by shuttling between two oxidation states, the redox Chemistry is involved; iron two and iron three is involved. And, that is basically responsible for generating the electron transfer chain.

Then, we can have the nitric oxide synthase. So, nitric oxide in the biological system in our body also; if it is required, then this heme-proteins are coming in to the picture. They play some important role and catalyzes and oxidizes also; where the heme- proteins are present. So, there are large number of molecules available in the biological system, where heme-proteins are involved. And, whenever simply we classify them as heme-proteins, we will see that the iron is typically bound to the porphyrin rings. It is basically the corresponding chemistry of iron and porphyrin.

And, biosynthetic path ways are available where the porphyrin is synthesized in the living system. But in the laboratory also, the chemically known molecules are there where we can find and we can synthesize the tetrapyrole unit nicely such that, we can have the corresponding tetrapyrole molecules which can bind to the iron system and we …and we studied the simple iron porphyrin system related to the corresponding heme-proteins. So, that gives us a very important area which is known as the corresponding Biocoordination Chemistry under bioorganic Chemistry.

So, whenever we talk about the corresponding bio coordination, so we should be talking about the corresponding ligands which are available in the living system. So, living system have some ligands. When it binds to the metal ion, we can consider that biogenic ligands; ligands of biological origin is coming and binding to the metal system.

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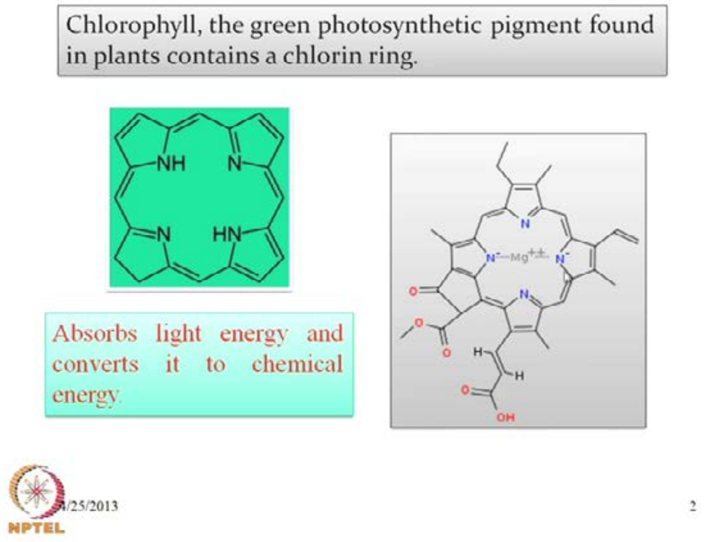
Chlorophyll, the green photosynthetic pigment found in plants contains a chlorin ring.

Absorbs light energy and converts it to chemical energy

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So, there are some more important examples are there. The next one, the second one is well known to us is the chlorophyll, the green pigment which is responsible for the photosynthesis in plants. So, this green photosynthesis pigment in the plants contains some chlorin ring. So, this is chlorin ring. So, compared to the porphyrin ring we can have different types of ring. But, that is also a pyrole system. But the connectivity is different. That is why it is binding a different metal center and it is showing some different type of reactivity. So, this is very much close to that particular tetrapyrole unit. That means the porphyrin unit.

So, now we can simply look at the corresponding difference. Only this particular ring is the reduced ring. So, whenever we have some important observations related to this, here also these particular important observations we can have. So, this is also containing N H and N H; that means this ligand can function as L two minus through the protonation and nicely it can bind to a metal ion, which can have a two positive charge. So, a bipositive metal ion can bind nicely to this particular system. And, when one particular ring is different compared to the pyrole unit;

that means when we reduce this thing, that means we are reducing the corresponding rigidity of the macrocyclic structure.

So, already we have put some extra rigid structure to this; because this we can have some idea about the corresponding macrocyclic living. What we have discussed earlier that if this ring is not there, this ring, this ring and this ring, so if four rings are there, not there, so from the tetraammine system we can also have a corresponding macrocyclic ring. But once we put this rings, the system is getting more and more rigid structure. And, that rigid structure is responsible for some photochemical activation of these things also.

And, once compared to the porphyrin ring, if we can have some reduced structure of this particular version, so we can have some different types of orientation of this particular ring; because here also we can have some suitable substitutions on these positions of the pyrole ring. So, the actual structure of this is completely different for this; because not only this chlorin ring. So, this chlorin ring is there, and in presence of this photosynthesis it is binding to a… metal ion. It is not binding to the typical transition metal ion like iron in hemoglobin and myoglobin, but it is binding to the magnesium. But, still it is colored. So, the color is not due to the presence of magnesium, it is due to the presence of these all other rings which are present in this particular organic molecule; because organic molecules are sometimes colored. They can have the different type of transition the … of transition.

So when we have this magnesium, initially we can consider that it can have some interaction because these two nitrogens through the protonation of these nitrogens are charged. So, the charge is there which is N minus and this is also N minus. And, due to that charge interaction we can consider the magnesium can have a coordination number of two, sitting nicely inside this particular pocket. So, what happens? When a tetrapyrole unit is coming to us we can have some initial binding from two of these nitrogens. Then, all four nitrogens start interacting with the metal center. But, in actual sense these two nitrogens are also shows some bonding interactions with the magnesium because the pocket is there. And once it is fitted within the pocket, these two nitrogens are also showing some interactions. And, ultimately we can get the corresponding structure where the presence of magnesium enhances the rigidity of the entire molecule.

So not only this is a tetrapyrole system, but also we can have in this particular site; where we just basically get the corresponding nitrogen, which is basically air. And, we have a cyclopentanone ring. So, attached to this porphyrin, only one of this porphyrin where we do not have the corresponding substitutions. We will have a cyclopentanone ring and we will have some ether backbone also. So, this cyclopentanone ring is also enhancing the corresponding rigid structure of this. So, this particular rigidity of the molecule is responsible for light absorption; because the photosynthesis is basically is a basically a photochemical reaction where H nu is activating for one sort of electron transfer from this particular system to the reduction for the carbon dioxide.

So, this particular type of binding for a non-redox system, so they will… if there is an electron transfer, it is not due to the presence of this metal ion. So, is this particular system basically is responsible for absorbing the light energy. It is most suitable for absorbing the typical light in the form of H nu and it converts to the chemical energy. So, the Coordination Chemistry, the metal and the ligand system is also responsible for light harvesting. What you call that? It can absorb some amount of light energy and absorption of light energy is only dependent on the metal ion coordination; because the free backbone, the free ligand is not showing that activity for light absorption.

And, only it is specific to some metal ion which is magnesium and synthetically prepared, which we can prepare in the laboratory and substitution of this metal ion by some other metal ion also, so that they can show some amount of light absorption. That means that spectroscopic properties they can show, but in the living system where the plants are utilizing the photosynthetic green pigment for light absorption in a particular web length, so and that particular web length is responsible for the green color of the leafy material. So, all the leaves are green. So this green material, the green part is coming out. So other part, the red part it is absorbing and that particular web length is responsible for the typical excitation. So, metal ion coordination to some biological ligand is responsible for light absorption in photosynthetic reactions.

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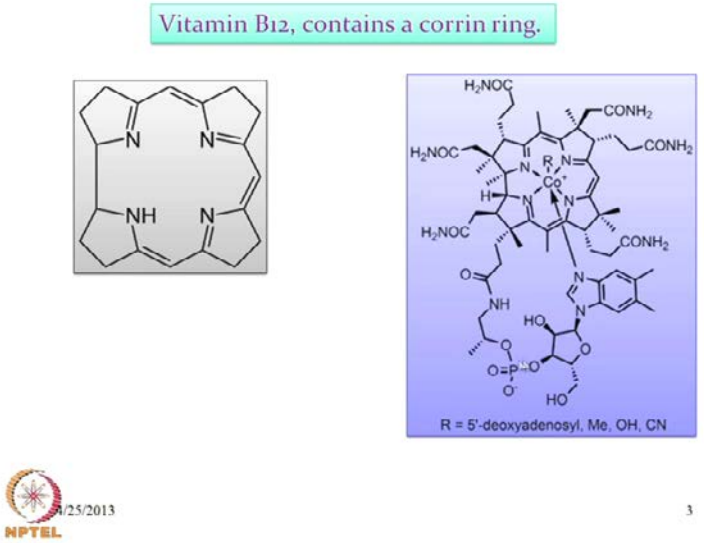

Vitamin B12, contains a corrin ring.

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So, we will see some other type; that means the third category of these molecules which is belongs to the vitamin B 12. And, vitamin B 12 now contains a corrin ring. So, we can have porphyrin, we can have the chlorin ring and we can have now the corrin ring. So, these are all just moving from one system to the other. And here also, we see that the connectivity is again through the four pyrole ring. And in some cases they are reduced, and this particular system when we can have a different metal center is utilized to bind. And this is the corresponding cobalt system. So, we can have a different type of metal center and we can have a different type of ligand for its coordination to give us a vitamin system.

So, we have this particular ring. So, this is fully reduced ring. And the nature of this, we can compare with the porphyrin because the structure would be definitely different when it is in the free state. That means, when it is not bound to the metal ion, in the free state it has a different structure. And, this particular connectivity is also different. We do not have the methyne connectivity, these carbon is not there. It is a direct connectivity between these two five membered heterocyclic nitrogen bearing rings.

And, this connectivity is making or giving us some smaller cavity size between these four nitrogen. And, we can have one N H group is available only. So, basically this ligand can function as L one minus. And, the structure is also different, so it can have some different binding potential to the metal ion cobalt. And, when it is binding to the cobalt center, and most of the reactions we get which is best on the cobalt one; because it is providing only one negative charge, but the entire connectivity of the system is pretty complicated because in case of porphyrin, in case of myoglobin, we have the corresponding venal substitutions. We can have the corresponding propionic acid site groups, but here the biosynthetic route is little bit complex to give us some pendant groups which are there on the substitution positions of the pyrole ring as the corresponding amide functions.

So, most of them are amide. So, six of these positions are amide functions, then we can have the dimethyl functions. Here also we can have the methyl substitutions. So, it is pretty crowded molecule, but the living organisms do synthesize in our system. So, nature is taken certain codes of reactions where it can be synthesized nicely within our system, within our living system.

And like myoglobin, it also binds to a nitrogen heterocycle which is benzimidazole. Not the imidazole, but it is the benzimidazol… So, again the fifth position is coordinated through some gen type of thing. It is already connected to the ring, some phosphate back bone and the sugar unit. The phosphate back bone and the sugar unit is controlling the corresponding binding to the imidazole…. And, the sixth position like O 2 binding to the iron center in blood, this R is a typical one which we get. Most of the cases, the corresponding compound is known as cobalammine.

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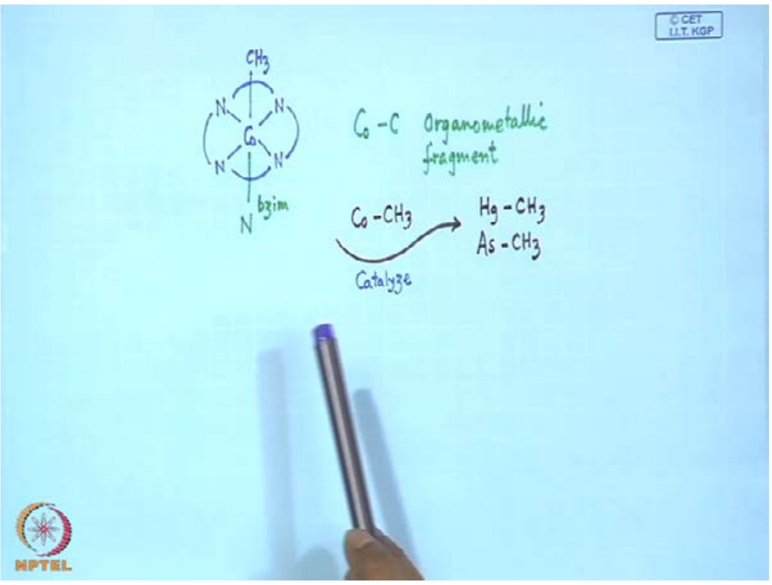

And in the cobalammine, if this is bound to a methyl function, the methyl group known as the methylcobalamin function; where we can have the strictly the carbon group of the methyl group, it is directly bound to the cobalt center giving a corresponding… this is the nitrogen of benzimidazole group. So, what we get here is basically a cobalt carbon bond also. And, the metal carbon bond we all know that it is the corresponding organometallic fragment. This organometallic fragment, for this is the nature's first organometallic compound which we are finding in vitamin B 12. And most of these reactions, what is basically we are getting? This R dominated by the corresponding cobalt methyl functions.

So, this has also catalyzing some important reactions such as the formation of the corresponding methyl mercuric compounds; because these compounds are easily formed. Then, corresponding methyl arsenic compounds; these compounds are all catalyzing through this particular type of vitamin B 12 or the B 12 like molecules. So, they do catalyze the corresponding conversion of typical metal salts because these are the corresponding salts. This is can be the corresponding mercuric chloride; this can be corresponding arsenic oxides… the corresponding…chlorides. And, they are immediately converted through the use of any methyl cobalammine type of catalyst to the corresponding methyl… of the metal ions.

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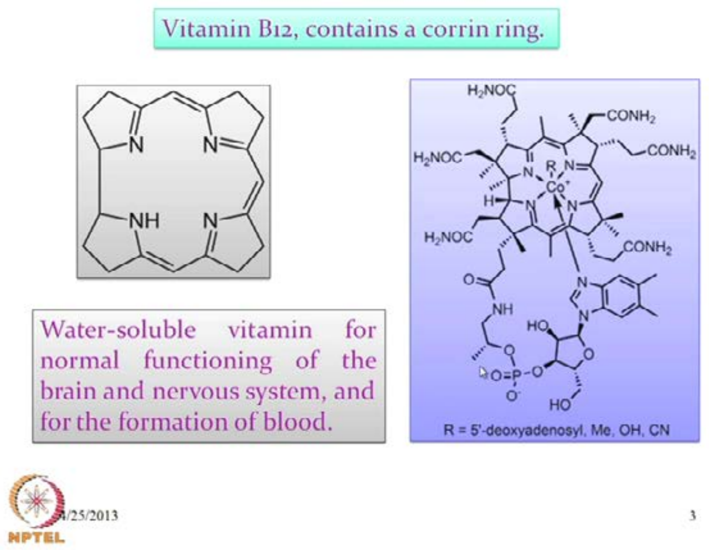

Vitamin B12, contains a corrin ring.

Water-soluble vitamin for normal functioning of the brain and nervous system, and for the formation of blood.

R = 5'-deoxyadenosyl, Me, OH, CN

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So, these are therefore some interesting group of molecules which can catalyze number of reactions; particularly some reactions which can take place also in our body; so, the chemistry which is going on in our body, so that it can be hampered basically by some biochemical path ways also. It is well known to ask that it is the water soluble vitamin compound for availability is very much required. It is also used as some medicine. When we have the shortage of these vitamins, we should be supplemented by use of vitamin B 12 or the cobalammine. So, some well-known brands of vitamin tablets and capsules are available which contains cobalammine. Because they are required for the normal functioning of brain; when there is shortage, there is some abnormality in the brain functioning, our nervous system.

So, very important reaction systems are there. And, the formation of the blood, the formation of the myoglobin and hemoglobin molecules are also catalyzing by the presence of this important cobalt compound that, the cobalt coordination compound of a good biologically available ligand, which is our corrin ligand.

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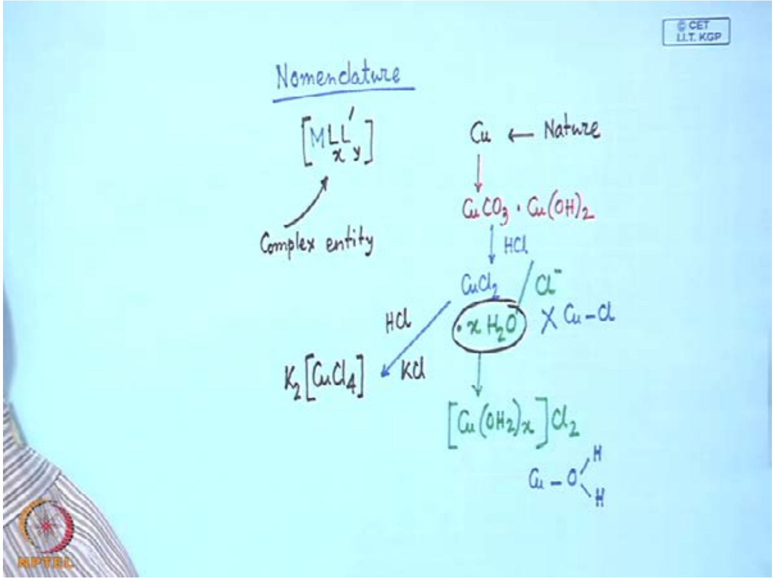

So, next we will just proceed for the nomenclature of this coordination compound. So, the next part of today's lecture we just devote to the corresponding nomenclature, how we name a typical coordination compound; because we can have a corresponding species which is made up of the metal. And, several ligands will be there, L can be there, L prime can be there and which is x and which can be y. And, within square bracket we consider it is the corresponding, this is basically the corresponding complex entity.

So, how we name the complex entity systematically within a metal complex? That, we will just see. So, how we name a particular coordination compound? So once, simple compound is forming, so how we just go for naming a typical coordination complex? So, what we do? We the first focus our attention on the ligands, and ligands should be named in an alphabetical order. So, depending upon the name of the ligands we should have a choice. And, in alphabetical order we will just name one after another. So, this is during the naming which would this completely different when we write in the formula. And, that is also another task that how we write a typical formula for a metal complex.

So once the ligands are named, we go for naming one after another ligands. Then, we go for naming the metal ions. And then, we write down the oxidation state of metal ions and which is subscribed by the corresponding roman numerals in the bracket. That means, if we have a corresponding oxidation state of iron as two. We will write in roman numerals that it is a giving as a corresponding middle complex in plus two oxidation state or if it is a corresponding oxidation state of say manganese in plus four. So we will write in the roman numeral within bracket after manganese; that manganese is present in plus four oxidation state.

So, some of this information we can also find it in Wikipedia also. And, these are very common and right informations. Everybody should have this information nowadays because whenever we are talking about something, we talk about some mono dentate ligands. The most important and the most common ligands system is the monodentate ligands, which we will see that copper that is available in our nature. So, how nature is giving us the copper? Nature is not giving us the copper as the copper metal. So, we do not go for mining to get the corresponding copper in the nature.

So, we get some important compounds or important corresponding inorganic compounds like copper oxide, copper sulphides and all. And if you see that, we get a corresponding compound like say copper carbonate or sometime we will get as the basic copper carbonate; that means copper carbonate copper hydroxide double salt.

So, if these are there and if we dissolve them in hydrochloric acid, we get a corresponding salt of copper chloride. So, what we see that copper chloride so long it is in the salt… structure. And, we are not getting this as the correspond interactions. So, we do not have any idea about whether they are C l minus groups. So, this C l minus groups are the most important monodentate ligand system which is also charged. So, this can go and bind to the copper and giving rise to a corresponding copper chlorine bond. But, in such other cases we will find that if it can help some x number of water of crystallizations. If x number of water of crystallizations are present, we immediately end up with some other form of this salt which we will write as bound water molecules, which is like this. And, we will be writing the corresponding chlorides outside the coordination sphere.

So, we get that is not having some copper chlorine bond. So, copper chlorine bond is not there, instead we have some oxygen bond. So, depending upon its coordination number of number of water molecule bound to copper, so we have the copper oxygen bond. So, what we see that if we can make this, that means, this particular species which is present as this one; that means, we can go for its corresponding anhydrous form. That means this water will be lost. So, if we just go for the corresponding anhydrous form and we just supply some amount of say hydrochloric acid or the corresponding potassium chloride or any other salt, whether we should be able to form a corresponding compound like C u C l 4 which will have two negative charge. And, if potassium chloride is supplied, we will be getting as K 2 C u C l 4 salt.

Now, water is not present and since four C l is there, which cannot be present as the corresponding anions outside the coordination sphere. So, all four copper chloride groups can be bound to the copper center and this can be a very good example for the corresponding coordination compound, where you can have the monodentate coordination of C l minus.

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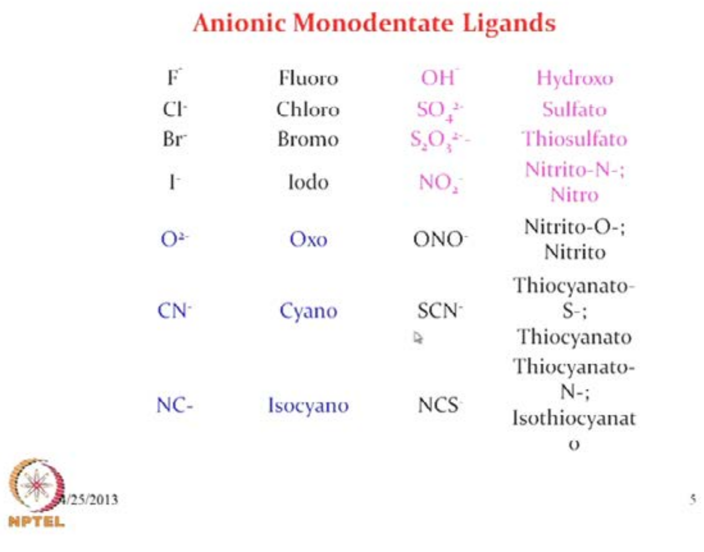

Anionic Monodentate Ligands

F^-	Fluoro	OH^-	Hydroxo
Cl^-	Chloro	SO_4^{2-}	Sulfato
Br^-	Bromo	$S_2O_3^{2-}$-	Thiosulfato
I^-	Iodo	NO_2^-	Nitrito-N-; Nitro
O^{2-}	Oxo	ONO^-	Nitrito-O-; Nitrito
CN^-	Cyano	SCN^-	Thiocyanato-S-; Thiocyanato
NC-	Isocyano	NCS^-	Thiocyanato-N-; Isothiocyanato

So, not only this C l, but also we can have the fluoro, bromo, iodo. So all these things, so when you will you are talking about some typical metals salts we should concentrate or attention on the corresponding species for this present, depending upon the number of species which is surrounding the metal center; that means the coordination number.

If four of this B r groups are there, they are minus. At present we get a corresponding tetra bromo complex. Similarly, from water derive species we can have two such hydroxo and oxo.

When C N is bound, we name it as Cyano; when C N is bound through this carbon, we got this isocyano; …thiosulphato through oxygen; nitrito or nitro and this is nitrito o and nitrito. So, these are the two forms. When it is bound through nitrogen, we call it as nitro; when it is bound through oxygen we call it as nitrito; that we will see when we will study the Isomerism; the Linkage Isomerism basically. Similarly, this thiocyanate anion can bind through sulphur and it can bind through nitrogen. And, we can have two different types of nomenclature. In one case, we will consider it as thiocyanato; in other case we will consider them as isothiocyanato.

So, linkage isomerism also we will discuss. And, in that particular case the nomenclature of the compound will define whether the metal center is typically bound through sulphur or through nitrogen.

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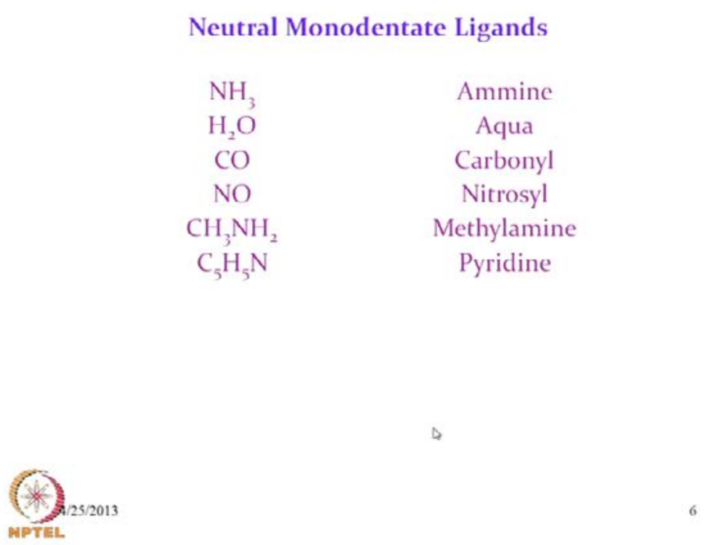

Neutral Monodentate Ligands

NH_3	Ammine
H_2O	Aqua
CO	Carbonyl
NO	Nitrosyl
CH_3NH_2	Methylamine
C_5H_5N	Pyridine

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NPTEL

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So, this is a part of the least what you can have for the charge ligands, then we can have the neutral monodentate ligands. As we all the time we were seeing the Ammonia is the very good ligand, very old ligand and very useful ligand to bind to a particular metal center performing large number of corresponding metal nitrogen bonds. That means the ammine complexes are plenty. Particularly the “father of Coordination Chemistry”, Alfred Werner, studied all this reaction starting from this ammine ligands.

So, whenever we have the typical metal salt like the corresponding ferric chloride of ferrous chloride salts, we see that the depending upon the hydration, number of hydration, we see that the water molecules are bound to the metal center. So, the aqua ligands were initially present.

Then, the addition of ammonia gives us the corresponding substitution of aqua ligands by ammines. Then carbon monoxide can bind to the metal center giving the corresponding carbonyl ligands, then magnesium oxide also and related to ammine. We can have the methylamine and pyridines.

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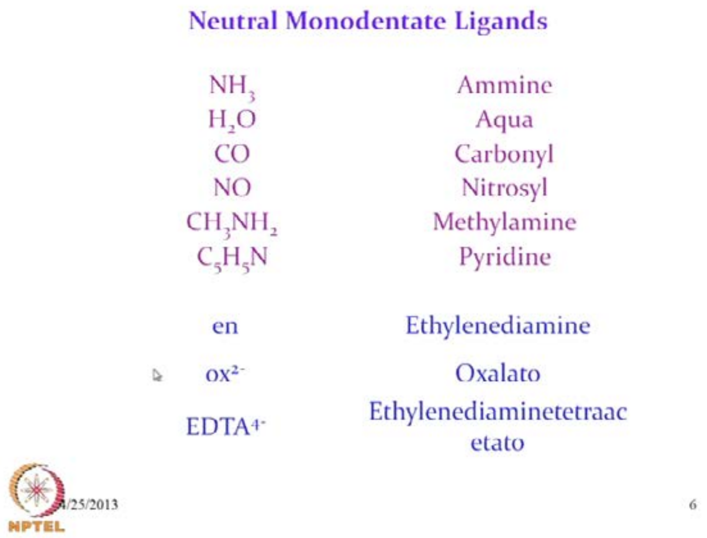

Neutral Monodentate Ligands

NH_3	Ammine
H_2O	Aqua
CO	Carbonyl
NO	Nitrosyl
CH_3NH_2	Methylamine
C_5H_5N	Pyridine
en	Ethylenediamine
ox^{2-}	Oxalato
$EDTA^{4-}$	Ethylenediaminetetraacetato

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So, these are the some list of neutral monodentate ligands. we can also have seen the… form of ethylenediammine. So, in the formula we will not write the big name of ethylenediammine, we will abbreviate it has e n. Similarly the charged ligand which is bidentate, also the oxylate ion from the oxalic acid, which binds to the metal center through two oxygen atoms are known as the corresponding oxalato group. Similarly ethylenediaminetetraaceticacid; on ethylenediammine backbone, if we substitute all four hydrogens by four acetic acid substrates, then we get the corresponding ethylenediaminetetraaceticacid. And, in the anionic form when four of them are deprotonated, we get ethylenediaminetetraacetato coordination.

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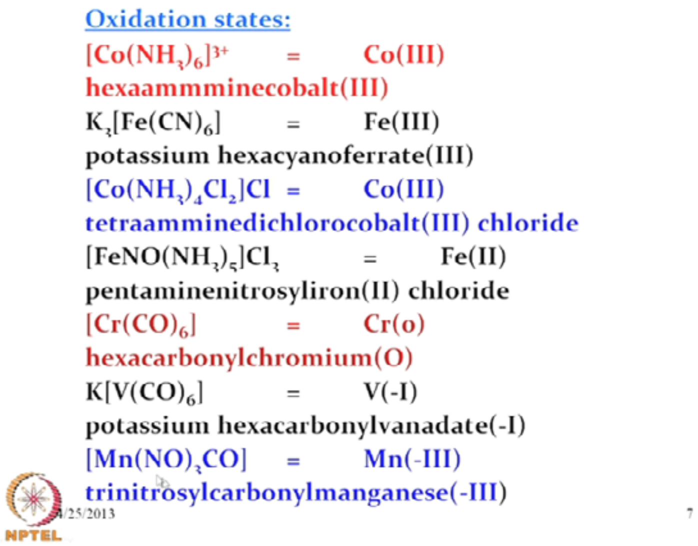

Oxidation states:

$[Co(NH_3)_6]^{3+}$ = Co(III)

hexaammminecobalt(III)

$K_3[Fe(CN)_6]$ = Fe(III)

potassium hexacyanoferrate(III)

$[Co(NH_3)_4Cl_2]Cl$ = Co(III)

tetraamminedichlorocobalt(III) chloride

$[FeNO(NH_3)_5]Cl_3$ = Fe(II)

pentaminenitrosyliron(II) chloride

$[Cr(CO)_6]$ = Cr(o)

hexacarbonylchromium(O)

$K[V(CO)_6]$ = V(-I)

potassium hexacarbonylvanadate(-I)

$[Mn(NO)_3CO]$ = Mn(-III)

trinitrosylcarbonylmanganese(-III)

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So, what we see next then? Ligand, then metal centers and how to find out the corresponding oxidations states. So, balancing the entire molecule we get the corresponding oxidation state. So, what we see therefore that, we are taking a very useful example of cobalt compound which we prepare from cobalt two chloride by the addition of ammonia.

So, excess ammonia when we put and if we start from cobalt task chloride, and in presence of activated charcoal we pass air or we add hydrogen peroxide. So, the addition of hydrogen peroxide or passing of air can oxidize this cobalt two, cobalt three. So, we have hexaamminecobalt three. So, this particular thing, that means, how you assign the oxidation state of this as plus three; because this compound will be known as the hexaamminecobalt three chloride.

So, if the charge on these because we have started our journey, we have started this reaction to make this particular compound from cobalt task chloride. So, through oxidation of this and additional chloride supply, we will give you this corresponding compound as C l 3. So, if we just measure the corresponding solution, electrical conductivity or the molar conductance, that means lambda M, so lambda M value will be different which will be corresponding to one is to three electrolyte type. And, that value will tell us that it has three chloride anions outside the coordination sphere. And, the corresponding oxidation state of this cobalt center is in plus three.

So, if we have a corresponding oxidation state; that means the charge, this particular charge, we should assign. And, cobalt then be designated as cobalt three in roman numeral. So, the name of this cationic species will be therefore the cobalt three, when we assign as cobalt three, which will be hexaamminecobalt three. If three chloride anions are outside, the full name of the compound would be hexaamminecobalt three chloride. Similarly, if this is there where six cyanide amines are bound to this iron site, and when it is bound to this iron cite and depending upon the charge, cyanide amine is providing; that means it is providing fixed anionic charge. And, this particular iron can have two oxidation states. One is plus two, another is plus three. In this particular case, if three potassium cations are required for charge neutralization, the iron oxidation state should be plus three.

If four are required, the iron oxidation state would be plus two. One is known as ferrocyanide; another is known as ferricyanide. So, in this particular case the name of the compound were potassium hexacyanoferrate; because we are naming this particular part as the anionic part. And, the anionic part would be named as the corresponding Latin name with some ending where the suffix as eight with the corresponding oxidation states in bracket.

Similarly, when we have the mix ligands, instead of six amine ligands we can have four amine and two chlorine inside. And, assignment of the oxidation state of the metal center is important. And, since four of these amine groups are present, we get the corresponding ligands as tetraammine. Alphabetically, we are writing A first, then dichlorocobalt three chloride. So, tetraamminedichlorocobalt three chloride is the corresponding naming for the required species where the cobalt center is present in the plus three oxidation state.

Then, we just change; that means instead of all ammine functionality on iron, around iron, we change one, two, N O the nitric oxide gas. That N O is present in some different form also through some internal electron transfer. This N O can be present as the corresponding charges N O plus, so this is as N O plus, this iron is F e 2 plus. So, we can have overall balance with the three chloride anions. So, iron will be present is in plus two oxidation state.

So, this is the well-known brown ring tests, we can have, where you can have the water molecule so that here. And, the … of nitric oxide, from the nitric oxide will bind to the iron center and brown ring compound. You know it can be formed, which is a test for nitrate and nitrite anions. But, immediately this N O is forming or transforming to the corresponding N O plus. That is why the assignment of these oxidation state is important and it depends on the corresponding nature of the N O. So, this particular molecule will be named as pentaammminenitrosyliron (II) chloride.

Similarly, one more example is that where like N O we just go for the corresponding carbon monoxide. Six such carbonmonoxide molecules can bound to the chromium centers, since carbon monoxide molecules are all neutral and we do not have anything outside the coordination sphere; that means outside the square brackets. So, that means your chromium center is in the zero oxidation state. So, the chromium zero also can give rise to the metal complex where carbon monoxide can nicely bind to the chromium center. So, not only this mononuclear species, there are large number of multinuclear species are also present.

And, that multinuclear species can have several types of these carbon monoxide ligands. So, in one case we can have this carbon monoxide, where all the six C O molecules are binding to the chromium center in monodentate fashion. In some other case, we can have the bridging carbon monoxide. And, some spectroscopic techniques are also available which can identify the nature of the carbon monoxide; not only in the mononuclear species, but also in some poly nuclear or the carbonyl…molelecule. So, the name of this compound through the assignment of chromium oxidation state as zero would be hexacarbonylchromium (0).

This also very good starting material for different types of chromium compound, organometallic chromium compound, where chromium zero oxidation is utilized. Then, vanadium can also give rise to similar type of carbonyl compound, but the corresponding charge on the vanadium is different; which is V one minus. Vanadium can be this particular one, can be because it is balancing the corresponding potassium charge as K plus. So, this is the corresponding anionic part, vanadium bearing part is the anionic part where carbon monoxide is neutral. Therefore, the vanadium is in the plus one oxidation state which will be known as potassiumhexacarbonylvanadate one minus. So, it is a potassium salt. And, like chromium it also has six carbonyl compounds, six carbonyl molecules surrounding the vanadium in octahedral geometry.

Then, the last example on this series is that nitrosyl of more number. Here the nitrosyl was present with one number. When three nitrocyl is present along with one carbonyl, we get the corresponding compound. And, manganese is present in minus three oxidation state which is trinitrosylcarbonylmanganese minus three. So, the manganese is getting some electron which is the back bonding from the carbon monoxide and the nitrosyl; because all these nitrosyl they are N O plus. So, that electron is basically dumping over the manganese. So, manganese is basically accommodating the corresponding more number of electrons. So, manganese is present in the minus three oxidation state; that means three extra electrons are transfer to the manganese site.

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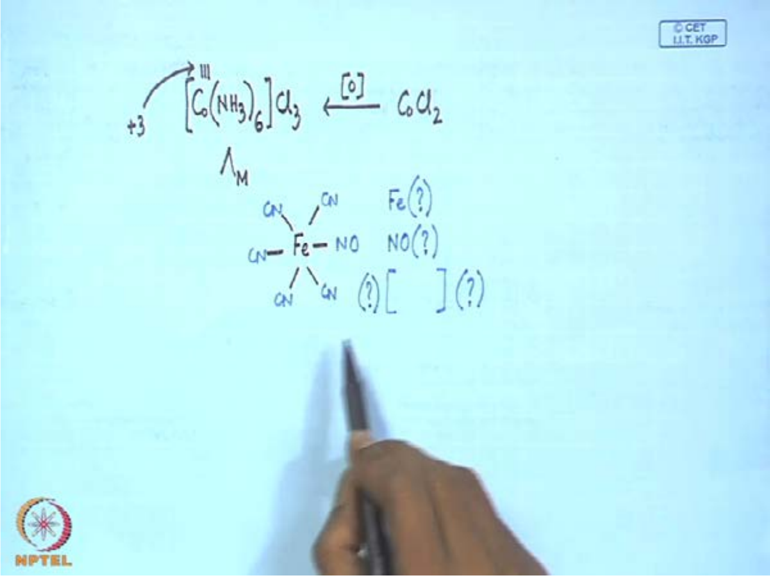

So, one more example we will just see, which will continue to our next class also. That is the very good example, where the ligands, which are present within the iron site is that C N and the N O. So two types of ligands are present, which is bound to the iron site; and for the typical charge balance, if we considered this N O as the N O plus, we get the corresponding compound of this, and how we just go for this particular compound; that we will continue to our next class.

So, we have this iron and we have six coordination sites. And this six coordination sites will all be occupied by C N. And one of them will be occupied by N O. So, the assigning of this iron oxidation state is important. That we will discuss. And that we will discuss, how we can assign the corresponding oxidation state on the N O and what should be the corresponding charge on this particular species that how many anions or how many cations will be there following or preceding the corresponding complex species; that we will try to find it out. So, that gives us the entire formula of the compound and that will also straight line the corresponding naming of that compound.

Thank you.