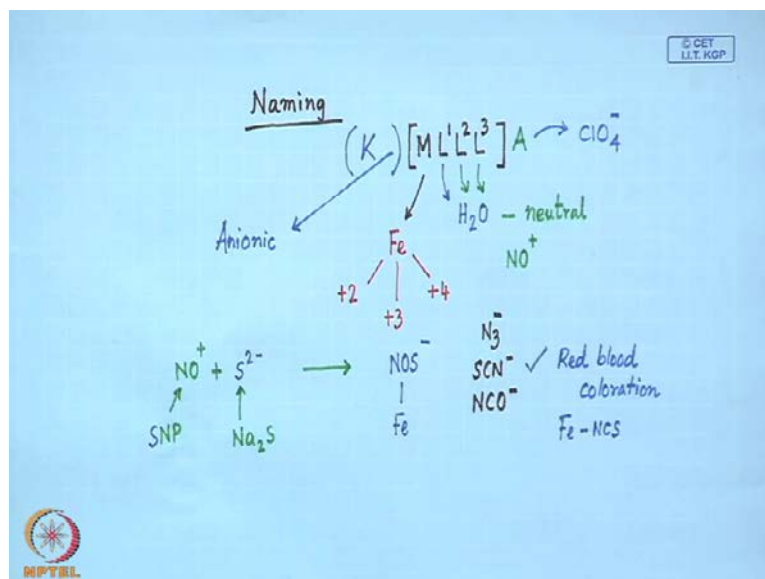


Coordination Chemistry
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Lecture- 6
Nomenclature – II

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Good evening everybody, so we were talking about the naming of the Co-ordination Compounds. So, how we systematically name one compound to the another, and in this case we basically considered the entire complex within the square bracket; then we have the metal, and the different types of ligands, say L 1, L 2, L 3, etcetera. And while doing so will find that this particular metal centre, say if it is iron we have iron there, and depending upon the nature of the different oxidation states, it can present there as plus 2 or plus 3 or plus 4.

So, whenever we name the entire compound will also detail the nature of the metal ion, what metal centre is present within the complex species. And it is different oxidation states, as well as the nature of the ligand, starting from the simple salt what we know after dissolving any metal salt in water, we get the corresponding aqua compound. So, when we put the aqua compound with that of the metal ion, in one particular oxidation state, will also explicitly define and state in the complete naming of the compound, that whether this particular ligand is present as a neutral species or anionic one or sometime

as the cationic one, when some of these compounds say some iron salt is reacting with NO as gas, nitric oxide gas, but it immediately giving up one particular electron and converted this particular species to the cationic species.


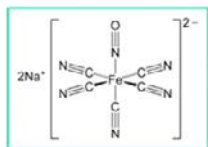
So, knowing the nature of this particular ligand, and its corresponding charges also important, because that will balance the corresponding positive charge what is available on the metal centre, as well as the other ligand say L 3 and L 2, this can be neutral or which can also be anionic.

And after that we can have something as the anionic charge balancing species, depending upon the overall charge of the complex species. If the overall charge on the complex species is cationic, if it is mono-cationic we will have 1 A of mono negative species; that means say per chlorate or nitrate or chloride. If it is a di-cationic complex species will have A 2 or some di-cationic species like sulphate. Similarly, if this particular complex species, this can also be present as an anionic fragment also.

And in that case to balance the charge we will have some cationic species like A, so depending upon the charge on the anionic complex part, we will have the corresponding cationic species, it can be very well the same potassium ion or sodium ion or ammonium ion. And the corresponding charge that means, how many potassium or how many sodium or how many ammonium ion, would be required to counter balance, the corresponding charge on the anionic complex.

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Nomenclature-II

$\text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}] \cdot 2\text{H}_2\text{O}$

$$\text{K}_4[\text{Fe}(\text{CN})_6] + 6 \text{HNO}_3 \rightarrow \text{H}_2[\text{Fe}(\text{CN})_5(\text{NO})] + \text{CO}_2 + \text{NH}_4\text{NO}_3 + 4 \text{KNO}_3$$

$$\text{H}_2[\text{Fe}(\text{CN})_5\text{NO}] + \text{Na}_2\text{CO}_3 \rightarrow \text{Na}_2[\text{Fe}(\text{CN})_5(\text{NO})] + \text{CO}_2 + \text{H}_2\text{O}$$

with nitrites

$$[\text{Fe}(\text{CN})_6]^{4-} + \text{H}_2\text{O} + \text{NO}_2^- \rightarrow [\text{Fe}(\text{CN})_5(\text{NO})]^{2-} + \text{CN}^- + 2 \text{OH}^-$$

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So, will the second part of this nomenclature part of the complexes will see, that one particular example we have taken here, where the iron centre is present and what we are just discussing, that we have the NO as some species present. And it is a well-known compound, from our school days, we all use this particular compound as a very good analytical reagent. So, metal complex of iron can serve the purpose of an analytical reagent, which can detect very nicely the presence of some other species; that means, this complex can have some characteristics signature, which can be changed, if it reacts with some other analyte.

So, metal complex can react with some other analyte to give some change of the property of the metal complex that means, some of the part of the metal complex, it can be the metal ion, it can be the other part. That means, the ligand the first ligand is CN^- cyanide ion, or the nitrosyl cationic, this NO is present over here as NO^+ as nitrosyl cationic. So, the entire compound can react with sulphide ion S^{2-} for it is detection and this NO^+ is basically reacting with S^{2-} giving rise to the corresponding, another anionic species, which is NOS^- .

So, we can name this particular complex, because it has all these things has they are the metal is present, this can be considered as L_1 , and NO can be considered L_2 . And this particular part the entire part is the anionic part, so we need the presence of k that means, the potassium or the cationic part, and this particular cationic part can be counter balance the corresponding anionic charge on the complex, and the number of water molecules as water of crystallizations.

So, this particular compound nicely, when we name the compound we should have some good idea about what type of compound is it, so we have four cyanide ligand, so all of them are same. And one is NO , so NO is binding towards the iron centre through its nitrogen atom. So, directly you can have this iron nitrogen bond coming from the NO and we have the 2N^+ , because the complex species has 2^- negative charge.

So, how we can name this particular compound, and the nature of the compound is also well known is a very good red crystalline dark red crystalline compound is in powdered in nature also. And since it is sodium salt because we can have all other different salts also possible, we can go for the corresponding potassium salt, we can go for the ammonium salt as well. But, this particular compound is very easily made in the

laboratory, and rate beautiful compound is basically give us the corresponding good solubility in water, because this complex is a sodium salt.

And as we all know the sodium salts are highly solvable in water, so it has good solvability in water, and in water it gives some red colored solution. So, when this compound reacts with sulphide anions say S^{2-} , and this S^{2-} can come from sodium sulphide, and this basically react with NO^+ present in sodium nitroprusside. So, this which is present this fragment is nitroprusside NP_3S or we can fully name as when it is sodium salt, so it is SNP sodium nitroprusside.

So, when they are reacting it basically gives us NOS^- . So, which is very much similar to some other pseudo halides like azide, which is also having 3 atoms, so 3 atom anionic species or thiocyanate anion or NCO^- anion. So, the characteristic reaction towards the complex formation is well known to us, as we all know a solution of iron in the ferric state that the solution of the ferric chloride in water, immediately reacts with the thiocyanate anion to give red blood coloration.

So, it basically gives red blood coloration that means, we can detect the presence of thiocyanate anion by knowing the color change from a very light yellow solution of ferric ion, by the corresponding SCN^- anion as potassium thiocyanate, ammonium thiocyanate which is also colorless. But, when it goes to bind to the iron centre, it gives a every characteristics red blood color, which can be identified as a formation of the complex species based on $Fe-NCS$ bond.

Similarly, here also the in citugeneration NOS^- of sodium nitroprusside, which is still bound to the iron centre gives a corresponding color change, we get a violate coloration from a change of the red color of sodium nitroprusside. So, what we see that how we can name this particular compound, we can also know we can see how this particular compound can be very easily make from a well known another complex, which is potassium ferrocyanide, when $K_4Fe(CN)_6$, the iron is present in the plus 2 of oxidation state.

So, we have four potassium ions are required for charge balance, and this is known as potassium ferrocyanide. The iron oxidation state is important, it is in plus 2 oxidation state and it can be oxidized to its corresponding ferric form, which is $K_3Fe(CN)_6$

6 which is known as potassium ferrocyanide. So, for the synthesis of sodium nitroprusside from potassium ferrocyanide, we react it with nitric acid.

So, reaction of this particular species with nitric acid gives rise to the generation of this complex anionic species. That means, $Fe(CN)_6^{4-}$ where 5 N O that means this N O, that means, nitric oxide gas is in c two generated from nitric acid. The way we know that the different forms of nitric acid, the cold, the hot, the dilute, and the concentrated nitric acids can react with copper metal to give different nitrogen oxides.

So, this is a standard technique, where we can make different nitrogen oxides by reacting nitric acid with the copper, the metallic copper. Similarly, in this particular case also iron is present in plus 2 oxidation states, which is getting reduced during this particular transformation. And N O is forming; N O is generated in situ from the medium, so that generated N O is immediately going to react with thus efficient with expansion of $1/2 C_2N_2$.

So, $1/2 C_2N_2$ minus is removed from their and that particular position that means, $1/2 C_2N_2$ is going when we have all 6 C N groups are attached in the ferrocyanide. So, one is substituted by N O, so we get this particular anionic species, but in protonated form, that means H_2 salt, the corresponding H_2 salt is also possible with the liberation of carbon dioxide, and separation of ammonium nitrate and potassium nitrate.

Then in the next step, this acid form of sodium nitroprusside that means, the protonated nitroprusside, the protonated nitroprusside reacted with sodium carbonate. Since, it is also acidic in nature, it immediately reacts with sodium carbonate with liberation of carbon dioxide and water. And the compound is getting transformed to its corresponding sodium salt, so that is why we this is the procedure, where we can prepare sodium nitroprusside from potassium ferrocyanide.

So, this particular thing directly gives us that one particular potassium salt of the complex to it is corresponding sodium salt. So, there is one more technique also available for the production of this ferrocyanide this is a very interesting and nice molecule, which has importance for analytical chemistry as well as structure, and the corresponding iron complexes. So, like nitric acids were we are providing nitrate as (()) nitrates are also we are providing, and we all know this analytical test for nitrate and nitrides using the ferrous sulphate solution.

The cold ferrous sulphate solution in the laboratory is through the brown ring test, and that brown ring test also gives us the corresponding NO^+ plus attached to the iron centre with 5 water molecules there. Similarly, these two reactions, these two synthetic procedures that means, the production of sodium nitroprusside gives us these important informations that both nitrate, as well as nitrite ions can generate NO^+ species with the reaction of sodium or potassium ferrocyanide.

So, here NO^- is providing us with the corresponding NO^+ with the liberation of 1 CN^- anion and 2 hydroxide ions.

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Number of ligands: indicated with the prefixes di, tri, etc.

The exceptions are polydentates that have a prefix already in their name (en and EDTA^{4-} are the most common).

| | Normal | Polydentates |
|---|--------|--------------|
| 1 | mono | - |
| 2 | di | bis |
| 3 | tri | tris |
| 4 | tetra | tetrakis |
| 5 | penta | - |
| 6 | hexa | - |



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So, this differentiation for this type of ligands, and the number of ligands, because in this particular case what we see that we have two types of ligands, one is the corresponding CN^- , and another is the corresponding NO^+ . So, when large number of these ligands are present and during naming the corresponding compound, we basically indicate the corresponding numbers, as the corresponding prefixes as the di, tri etcetera.

That means, when we have two ligands, we call it as a di, when we have three size ligands we call it is tri, and when we have six or five cyanides we call it as a pentacyano or hexacyano species. But, the rule is not applicable to all when we have organic polydentate ligand that means, say some poly-ammines or amino acids are there when the ligands present, that means simple ethylenediamine, en is ethylenediamine.

And EDTA is Ethylene-Di-Amine Tetra-Acetic acid, when we are going for deprotonation it gives ethylenediamine tetra-acetate anions have 4 anionic charges, so this ligand has already ethylenediamine. So, diamine part is there, and which is ethylenediaminetetra di and tetra both the two terms are there. So, in that particular case we will consider instead of di or tri in the normal case of nomenclature like the presence of 4 chloride or 4 nitrates or 2 chlorides or 3 nitrates, we call them as bis, tris or tetrakis.

So, wherever we have the normal ligand nomenclature as mono, di, tri, tetra, penta and hexa will be consider as bis, tris, tetrakis, pentakis and hexakis, when we have polydentate organic ligands bound to the metal centre.

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$\text{CrCl}_2(\text{H}_2\text{O})_4]^+$: the ligands here are Cl and H_2O

Monodentate ligand - names of 'chloro' and 'aqua'.
Alphabetically, aqua comes before chloro.

There are 4 aqua and 2 chloro ligands, so we will add the number prefixes before the names.

Therefore, this coordination complex is called tetraaquadichlorochromium(III) ion.



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So, how we name this particular example of the complex, where chromium is attached to 2 chloride anions and 4 water molecules and the ligands present are there of two types. Like that sodium nitroprusside C L^- is 1 ligand which is anionic and water, as another ligand which is neutral, and forming the direct bond with the metal centre through its oxygen atom. So, when we have the monodentate ligands like C L^- or H_2O , we name them as chloro or aqua. And alphabetically will find that a is coming before c, therefore aqua names will come before the chloro.

And there are 4 such aqua molecules, and 2 chloro ligands, so we will also add the numbers as prefixes and since, these are not polydentate organic ligands will simply use the first type of nomenclature for the reaction, where we define the number of aqua

molecules and number of chloro ligands. Therefore, the naming would be like this, the coordination compound would be called as therefore, the tetraaquadichlorochromium III. So, we have 4 water molecules surrounding the chromium, and 2 chloride anions these are also the direct ligands and chromium is in plus 3 oxidation state.

How we know that, because we have two charges, two negative charges are balanced by C L groups, so this here, so definitely be in the trivalent state that means, in the chromic state. So, chromic ion is bound to 2 C L and 4 water molecules, so we get a typical octahedral molecule, since the complex is in here one square bracket will be there, so since the complex is in the cationic form that means, the cationic species we have. So, outside the coordination sphere we can have other mono negative anionic species, like nitrate or chlorate or C L.

So, if the entire compound, if it is a corresponding nitrate salt of the metal complex of C L and water ligands of chromium, we get the corresponding full name of the corresponding compound as tetraaquadichlorochromium III nitrate, if it is a nitrate salt.

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$[\text{CoCl}_2(\text{en})_2]^+$: Two types of ligands. Two chloro and two ethylenediamine ligands.

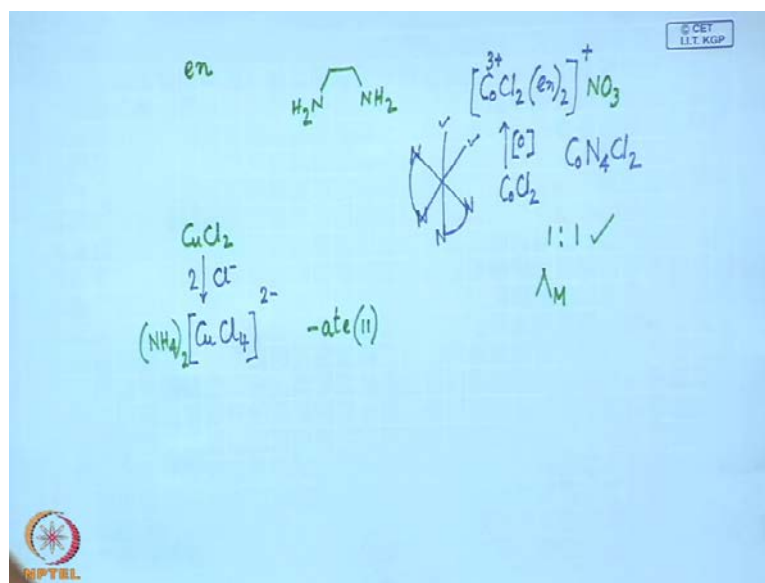
The metal is Co, cobalt. The en is a polydentate ligand with a prefix in its name (ethylenediamine), so "bis" is used instead of "bi", and parentheses are added.

Therefore, this coordination complex is called dichlorobis(ethylenediamine)cobalt(III) ion.



Similarly, we go for corresponding polydentate ligand, which is C o C l 2 e n whole twice.

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So, in this particular case what will see that we are bringing the polydentate ligand in our hand, that means the ethylene-di-amine which is N H_2 and N H_2 , and since the compound is cobalt $\text{C o C l}_2 \text{ e n}_2$. So, we have this ligand two of two such these ligands, two of these bidentate ligands are there, so if we have again 6 positions, and depending upon the cobalt oxidation state, if it is 3 plus we can go for the corresponding charge balance by 2 C l minus.

So, overall charge of this complex would be again plus, and two of this positions are occupied by C l which in most cases can come from the starting metal salt what we are using for the synthesis of the compound. That means, (()) that means cobalt 2 chlorides with some amount of oxidation by passing air or hydrogen peroxide, so two of these chlorides are still present with the cobalt and two more are occupied by these two bidentate ligands of ethylene-di-amine.

So, we get a typical octahedral compound, where the cobalt is bound to 6 atoms, 4 of them are coming from the nitrogens of ethylene-di-amine, so it is C o N_4 and two of them are C l 2, so $\text{C o N}_4 \text{ C l}_2$. Since, the charge is like this, so it can also be a corresponding nitrate salt which will be outside the coordination sphere, and we have overall charge of this particular b cationic complex species is plus 1 and this is minus 1.

So, we have a complex species which is 1 is to 1 type of electrolyte, and we can measure the corresponding solution electrical conductivity, or solution electrical conductance to

identify the corresponding nature of this particular compound. So, we have two types of these ligands, and metal we all know Co is cobalt, so we should be having a name where it can be prefixed with ethylene-di-amine, because already the name contains the di.

So, we cannot use di as the prefix of ethylene-di-amine, so di will be converted to bis as we have seen just now, in the list that bis will be used in before the corresponding number of ethylene-di-amines in the bracket. So, the compound would be dichlorobis ethylenediamine cobalt III ions is formed. So, if the complex species is written in the form of positive charge, we can call it as a cobalt III ion, but if it is the corresponding salt.

That means, nitrate salt or perchlorate salt will name it as dichlorobis ethylenediamine cobalt III perchlorate or dichlorobis ethylenediamine cobalt III nitrate.

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Naming the Metal Center & Oxidation State

The formal name of metal and the oxidation state should be known. To show the oxidation state, we use Roman numerals inside parenthesis.

The oxidation state of +3 for chromium and cobalt should be written as (III) after them. Copper, with an oxidation state of +2, is denoted as copper(II).

If the overall coordination complex is an anion, the ending "-ate" is attached to the metal center. Some metals also change to their Latin names in this situation. Copper +2 will change into cuprate(II).



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Similarly, we just concentrate our attention while we name the corresponding metal centre, and its oxidation state. Just now we have seen how we can assign the corresponding metal centre, if we do not know the corresponding exact oxidation state of the metal centre, if the metal center has undergone some oxidation like cobalt II to cobalt III by the oxygen present in the air or by using some reagent like hydrogen peroxide. So, assignment of the metal oxidation state is therefore important.

So, formal name of the metal and the oxidation state, we should know and we should number the corresponding oxidation state in Roman numeral within parenthesis. So, for plus 3 the chromium and cobalt should be written as roman III within bracket, but in case of copper the oxidation state of plus 2 is denoted as copper II. So, if we have the different oxidation state, so we should not have any confusion regarding the identified (()) of the oxidation state.

We should straightway name the corresponding oxidation state as plus 2 or plus 3 or sometime, we can have any metal oxidation state as plus 4, but if we see doing such operation on naming of this compounds, the overall charge on the complex is anion. So, we can have some metals are there, and we can have the corresponding name when it is copper we name this as copper II, if it is the corresponding tetra-amine copper salt, so we call it as a tetra-amine copper II ion.

But, when we have the corresponding copper II present, but more number of anions is surrounding the copper centre, giving a corresponding anionic charge on the complex species, we will name this particular copper centre as cuprate II. So, how we get that you just get, if we have copper II chloride in our hand, and if we see some amount of chloride ligands are still attaching to it, and if all the 2 chlorides the new ligands are attaching to the same copper centre.

The corresponding formula of the complex species would be $CuCl_4$, because copper has a typical tendency to bind four ligands around it, in a particular geometry, it can be square planer, it can be tetrahedral or it can be something related to some distortion related to these two geometries. So, when we have $4 Cl^-$ that means, more charge is accumulated on the di-positive copper centre, so overall charge on this complex species would be 2 minus.

So, in this particular case the naming would be completely different, and copper II will be named as now cuprate, cuprate with the identification of the oxidation state. Similarly, will can have the corresponding cationic also the cationics should be named first, so ammonium ion, if it is present completely balancing the corresponding negative charge on the complex species. We should name them ammonium ion also along with the corresponding ate nomenclature on the anionic form, so copper 2 will become cuprate II.

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The following change to their Latin names when part of an anion complex:

| Transition Metal | Latin |
|------------------|-----------|
| Iron | Ferrate |
| Copper | Cuprate |
| Tin | Stannate |
| Silver | Argentate |
| Lead | Plumbate |
| Gold | Aurate |

The rest of the metals simply have -ate added to the end (cobaltate, nickelate, zincate, osmate, cadmate, platinate, mercurate, etc. The suffix -ate tends to replace -um or -ium, if present).



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Similarly, there are some more Latin names, we can use compared to the common English name of other metal ions, if we iron is get that we all know that iron the symbol is Fe that means, it is coming from ferrous. So, when we use the Latin name for the from the corresponding anionic species, we call it as ferrate anion. Similarly, the copper we have just now seen would be cuprate in would be related to the stannate, silver would be named as argentate is related to the corresponding name basically Latin name of the element, lead will be plumbate, gold would be aurate.

So, the oxidation state will define and the anionic form will also define, but if we have the other metal ions not belongs to this Latin name, the other metal ion we simply have the ate nomenclature, cobalt addition of ate will be cobaltate, nickel will be nickelate, when we add ate when the species will be in the anionic form. Zinc would be zincate, osmium would be osmate, cadmium would be cadmate, platinum would be platinate, mercury would be mercurate etcetera.

And the suffix end tends to replace the um and ium, is present um and ium, so osmium was there. So, osmium was so (), so that ium has gone from osmium, and this has become osmate, similarly cadmium the ium is gone. So, cadmium become cadmate, and zinc is there, zinc full name is there with that of the addition of it. And if in other cases the is also there along with the ium, that also will go that will be replaced by simply ate.

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$[\text{Cr}(\text{OH})_4]^-$ - this complex is an anion.

There is only one monodentate ligand, hydroxide. There are four of them, so we will use the name "tetrahydroxo".

The metal is chromium, the complex is an anion, we will have to use the "-ate" ending, yielding "chromate". The oxidation state of the metal is +3.

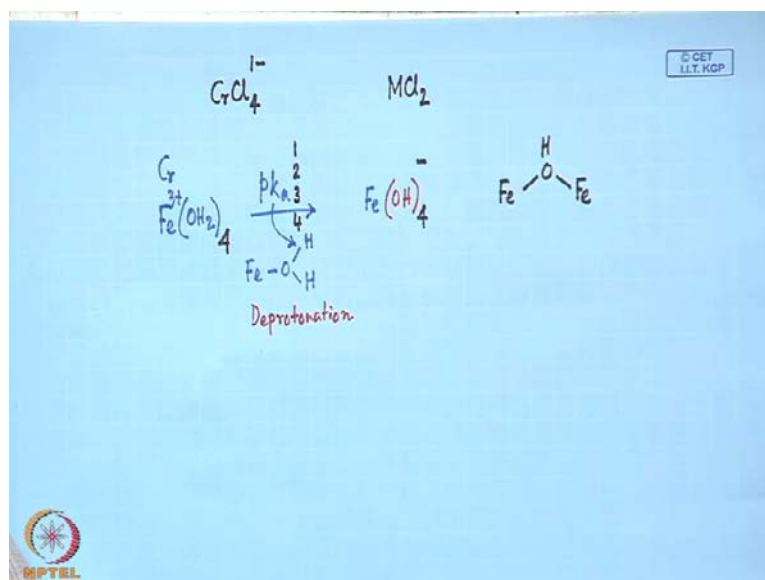
Writing this with Roman numerals and parentheses (III) and placing it after the metal we get tetrahydroxochromate(III) ion.



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So, that nomenclature will give us some good idea, about how we name the very simple species.

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Like that of addition of say CrCl_4 , if it is in the plus 3 oxidation state it would be CrCl_4^- , and why we are talking all these things, because these are very important, because most of the metal salts. We know can be available as it is corresponding chloride salt, very easily by the use of hydrochloric acid with the reaction of corresponding hydroxides or carbonates. So, these chlorides when they take up more number of

chlorides can be the corresponding example, very simple example for the anionic complex.

Similarly, when this chromium or iron or anything is bound to water molecule, the neutral water molecule, and we all know we have been discussing this when several our classes that when iron in plus 3 oxidation state is bound to one water molecule, we have so many of this type of Fe-O bonds, and the pK of this bonding will change, compared to the free water molecule. And will get immediate deprotonation, so deprotonation will take place, and this deprotonation will give rise to Fe-OH species from Fe-OH₂.

Similarly, if we can see that we have more number of these groups that means, if we just consider 4 such water molecules where their, and we can have 4 different pK values, pK₁, pK₂, pK₃, and pK₄. And after all deprotonation it gives rise to some Fe-OH type of species, which will have a negative charge because this type of species are very useful also, because when they are forming as they mono-nuclear fragment, it immediately can go for the breathing.

Because, compared to iron this hydroxide anion has some more potential which is more effective to bind two metal centre, and these are plenty in nature, in natural minerals and ores we find that corresponding oxohydroxido bridged iron centers are present. Also in the biological systems, the iron iron bound by oxo or hydroxo functions are plenty in number, so if we just see that the same thing is happening over a chromium centre.

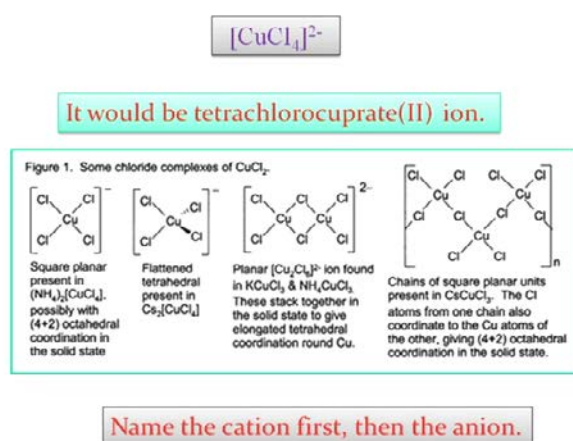
So, when we have chromium bound to 4 hydroxide groups, and the complex is thus becoming anion, because this chromium is present in plus 3 oxidation states. So, there are we have mono-dentate ligand, so we do not have any poly-dentate organic species present, so the tetra nomenclature is found instead of tetrakis, and hydroxo groups are there. So, tetrahydroxospecies is forming over there, and this tetrahydroxospecies is also possible for any metal centre.

Therefore, it can be with iron, it can be with cobalt, but it should be known to ask that only four ligands are present around these 2 chromium centre. Otherwise will be missing two other positions, if it is an octahedral 1 and if we write this one only we should consider that two other positions, the remaining two positions should be occupied by simple water molecules. So, the chromium we have, so already we know the rule that the nomenclature will be attached to chromium, with the elimination of -ium.

So, it will not be there, and the name would be chromate, because the oxidation state is plus 3, so we replace the name as 3. So, we have the naming of this compound this compound CrO_4^{3-} whole 4 minus would be tetrahydroxochromate III ion.

If it is a corresponding potassium salt will call it potassium tetrahydroxochromate III have a full stop over here only; if it is a corresponding ammonium salt, we name it as ammonium tetrahydroxochromate III. So, the name of the cationic part, though it is not a complex part is a simple inorganic part, so the simple inorganic part should also be named along with the complex part.

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So, will see next the most important species, what we are discussing that attachment of 4 chloride ligands around the copper centre. So, when we attach 4 such chloride groups, like chromium we have seen also, and in this particular case it is very easy to assume that it has only coordination number of 4. So, coordination number that will discuss in our next class that, if we have within the complex species only 4 bonds are forming between metal and ligand.

So, if we have only 4 metal bonds between, metal and ligand will consider this as a species where the metal centre has a coordination number of 4, and this is the limitation for some metal centre. Because, some metal centre can go low coordination number, like silver gold etcetera they can have a coordination number of 2, but in this case it is number is restricted to 4, it is not going to 5 and it is not going to 6 also.

So, the naming is very easy as we have learned now, it would be tetrachlorocuprate II ion, if it is ammonium salt, it would be ammonium tetrachlorocuprate II, so this ion part will not be there full stop will be here. So, some of this well known thing which is known in the literature, and is known in the books also that, how we can consider some of these chloride complexes of copper chloride, that is we are discussing.

That, this is a simplest cuprate chloride compound $CuCl_2$ is a simple cuprate chloride, and if it is reacting with more chloride, initially it can react with concentrated hydrochloric acid or any other chloride salt to give the $CuCl_4^{2-}$, it would be $2-$ minus $CuCl_4^{2-}$ minus. And if it is corresponding ammonium salt, so ammonium salt is NH_4^+ whole $2 CuCl_4^{2-}$, the naming would be ammonium tetrachlorocuprate II.

And if we want to know the corresponding structure in the solid state we grow the single crystals, and exceed the fraction gives rise to the corresponding molecular structure determined by x-ray diffraction. We get something where we find that this is basically is not a tetrahedral $1-$, it would be square planer $1-$ and in crystal state that means, in the solid state. In the solid state the crystal packing would be such that, this particular one this the, this chloride centre will share another chloride of the next molecule.

Similarly, from the bottom side, from the lower side it will also share another chloride of the next molecule, so share of these three end of the chloride groups makes one particular centre as a octahedral $1-$. And which is not a true octahedral one having 6 coordination sides of co-ordination number of 6, but it will be considered as a 4 plus 2 octahedral coordination 4 is formed the same metal ion, and 2 is coming out through sharing from the adjacent metal centers.

So, the ammonium salt would be crystallizing as the corresponding species, which would be octahedral in the solid state through sharing. But, if we just try to crystallize it, in it corresponding cesium salt, this would also be $2-$ minus like this is would be $2-$ minus only. So, cesium $2 CuCl_4^{2-}$ which is cesium tetrachlorocuprate, but this time the structure is different, because of this presence of this cationic because the size of the ammonium ion is small.

So, we can get the corresponding networking or some supramolecular interaction between the $CuCl_4^{2-}$ species for chloride sharing, because whenever we have

the corresponding crystal packing, we see that this is the anionic part, so cationic part will be coming in between two anionic parts.

So, there are some white spaces and white spaces would be occupied by the cationics, but in this particular case the size of the cationic is very less which is ammonium ion. So, white spaces are of different type and which is very small, and which is not inhibiting the corresponding sharing from the adjacent molecule through it is Cl. So, if we have the cesium which is a bigger cationic, individual species will remain as in a flattened tetrahedral structure, and we do not get such sharing of octahedral species.

Similarly, if we have one type of bridging of this can be obtained in some potassium salt or ammonium salt of this K_2CuCl_4 or ammonium $CuCl_4$ with a mixed of these two, we get the potassium ammonium salt of Cu_2Cl_6 . And this tag together to give elongated tetrahedral coordination, elongated tetrahedral geometry around this particular copper, and we have the corresponding sharing of these. So, we get a chloride bis dimeric form, similarly if the bridging is extended further.

So, it is another form of Cu_2Cl_6 , which is completely different from Cs_2CuCl_4 . So, this particular chloride this is in the chain form, so if the chain is continuing in the zigzag fashion. And one chain also coordinates to the copper atom to the other giving this also a 4 plus 2 octahedral coordination in the solid state.

So, in the solid state one chain of one particular plane is sharing the other chlorides from the other chain giving a typical octahedral, so copper centre the copper metal centre will always have some tendency to attract the other ligand, which is already bound to the adjacent centre of the copper. So, here also while we have the corresponding cationics present, the name of the cationic is coming first then the anion.

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$[\text{Pt}(\text{NH}_3)_4][\text{PtCl}_4]$: NH_3 is neutral, making the first complex positively charged.

Cl has a -1 charge, making the second complex the anion. We will write the complex with NH_3 first, followed by the one with Cl (the same order as the formula).

The name would be tetraammineplatinum(II) tetrachloroplatinate(II).

Problems

Write the name of the following complexes-

$[\text{CoCl}_3(\text{NH}_3)_3]$; $[\text{Co}(\text{ONO})_3(\text{NH}_3)_3]$; $[\text{Fe}(\text{ox})_2(\text{H}_2\text{O})_2]$;
 $\text{Ag}_2[\text{HgI}_4]$



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Now, is a another typical example of the complex, where both the cationic part and the anionic part are the complex fragment that means, we are not taking the help of any ammonium salt or any chloride or nitrate salt. We have made the two parts, the cationic as well as the anionic part as the complex species, so NH_3 is a neutral, so your first part is cationic and chloride is anionic.

So, the second part is anionic, so this is cationic, this is anion and it is going for the corresponding charge balance, so will write first the corresponding ammonium complex, the ammonia complex followed by the corresponding chloride complex. Because, the chloride complex is correspondingly anionic, and the name would be therefore, tetraammine platinum 2, the cationic part and the anionic part is tetrachloroplatinate II.

So, is the anionic part and the platinate II nomenclature is operating over there, so we get a complex species where both cationic and anion are of complex nature. So, we can try with naming some more as a problem, where we have the octahedral cobalt centre, where 3 chlorides and 3 ammonia molecules are attached; similarly, we have the cobalt in our future classes will discuss the isomerism.

Where the isomerism will tell something related to the binding of the nitrate anion differently to the cobalt centre, which is through oxygen here, we have the cobalt oxygen bonds which are 3 numbers. Because, we do not have any mixture between these that means, one is bound to nitrogen and another is bound to oxygen, but all are of same type.

That means, the nitrite is binding towards cobalt, 5 oxygen atom, similarly 2 oxalate like ethylenediamine is bound to iron centre, and we have 2 water molecules, and this is also not a complex species of mercury, but is a complex species of the salt of silver. So, is a mercury belongs to the corresponding complex part, which is tetraiodo mercuric anion, and it is corresponding cationic part is the corresponding silver 1.

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$[\text{CoCl}(\text{NO}_2)(\text{NH}_3)_4]^+$ → This is called tetraminechloronitrito-N-cobalt(III).

N comes before the O in the symbol for the nitrite ligand, so it is called nitrito-N. If an O came first, as in $[\text{CoCl}(\text{ONO})(\text{NH}_3)_4]^+$, the ligand would be called nitrito-O, yielding the name tetraamminechloronitrito-O-cobalt(III).

Nitro (for NO_2) and nitrito (for ONO) can also be used to describe the nitrite ligand, yielding the names tetraamminechloronitrocobalt(III) and tetraamminechloronitritocobalt(III).



So, if we have more than two that means, we have now the numbers of ligands are more that means, L 1, L 2 and L 3 and depending upon the corresponding charge their amine will be named first which is a neutral 1. So, the naming of the compound would be tetramine, then alphabetically chloro will come next, then nitrito which is bound to cobalt through nitrogen.

So, it is tetraminechloronitrito-N-cobalt, so N cobalt means it is immediately showing us that it is bound to the centre through nitrogen, so it is one isomeric form which is not bound to oxygen, but it is bound through nitrogen. So, it is bound to cobalt III, so it is the cationic form. So, it is a cobalt III ion, the name would be cobalt 3 ion, the in this particular case the other isomer which is binding through oxygen, so will instead of nitrito n we have nitrito oxygen also.

So, the naming would be in that particular case when NO_2 is change to ONO will get tetraminechloronitrito O cobalt III ion, again it would be cobalt III ion, but instead of

saying nitrito, and nitrito distinction we simply write nitrito N and nitrito O mentioning that cobalt is bound through oxygen, and bound through a nitrogen.

So, instead of nitro for N O_2 and nitrito these are some older definition that with write one it is bound to nitro, we call it nitro and when it is bound through oxygen, we have the nitrito. So, either we can write in the nitro or nitrito form or then modern nomenclature we just write as nitrito-N and nitrito O bind towards the cobalt centre.

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Formula of Coordination Complexes

Name → Formula

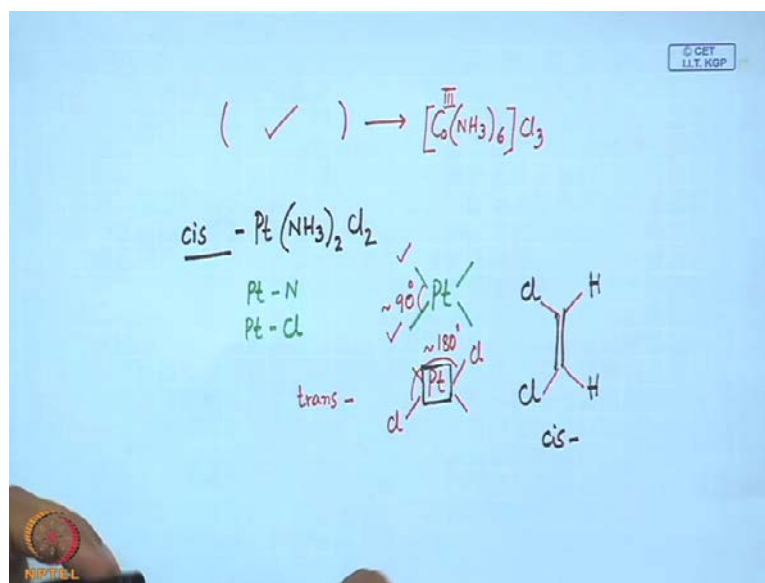
The formula of a coordination complex is written in a different order than its name. The chemical symbol of the metal center is written first. The ligands are written next, with anion ligands coming before neutral ligands.

If there is more than one anion or neutral ligand, they are written in alphabetical order according to the first letter in their chemical formula.



Now, once we write this particular species as the corresponding compound, the name is in our hand.

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Now, the reverse one that when we have the name, one particular compound name is given and you have been asked to write the formula, so what type of formula you can have, if is a very simple one having 6 ammonia molecules around it. So, how will you write, so once we know the name from here which is hexamine cobalt III chloride.

Once we know the things that means, when we write the name of over here as hexamine cobalt III chloride, we should be able to write nicely the corresponding formula of the compound. How we write cobalt it is corresponding charge, knowing the corresponding charge on it, and the number of ammonia molecule and number of Cl, because we have several other isomeric composition where more number of Cl minus will come within the coordination sphere.

So, the name will be in our hand and will write the formula from there in different order than it is name the chemical symbol of the metal centre is would be first. The ligands next with anion ligands coming before the neutral ligands, if more than one anion of neutral ligands is present will be written as alphabetical order, according to the first layer in their chemical formula. So, these are the different things that we just consider that the ligands, the naming of ligands with anion ligands coming first before the neutral ligands.

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When one of the ions is just an element, the number of atoms is not indicated with a prefix. Since it still has to be written in the formula, it is determined by balancing the overall charge of the compound.

Tetrafluorochromium(VI) *chloride* becomes $[\text{CrF}_4]\text{Cl}_2$.

Amminetetraaquachromium(II): $[\text{Cr}(\text{H}_2\text{O})_4(\text{NH}_3)]^{+2}$.

Neutral ligands are ordered alphabetically, with H_2O before NH_3 . (Their order in the formula is the opposite of that in the complex's name since one uses their chemical symbols and the other uses the names of the ligands.)

Amminesulfatochromium(II): $[\text{Cr}(\text{SO}_4)(\text{NH}_3)]$. SO_4 is an anion, so it comes before NH_3 .



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So, once the name is there just and the element the number of atoms is not indicated with a prefix, since it still has to be written in the formula, it is determined by balancing the overall charge of the compound. That means how many anions are required for charge neutralization, such as this which is tetrafluorochromium 6 chlorides it becomes CrF_4Cl_2 . So, we are not writing that it has 2 chloride in italic form is a chloride or the number of chlorides we do not mention, we just only see the charge on it, the oxidation states of the chromium. And how many chlorides are required for charge balance; then it would be CrCl_2 , then it would be CrCl_2 or CrCl_3 .

Similarly, for aminetetraaquachromium II, we have this water then amine functions and we just go for the corresponding charge neutralization, and we see that 2 anions would be required. So, when we have all neutral ligands we alphabetically ordered them, so with water before NH_3 , so water will come first, alphabetically then ammonia will come which is opposite to that in the complexness.

Since, one usage the chemical symbol and other is the name of the ligand is one case we use the names, in another case we are using the corresponding symbols. So, we have the amminesulfatochromium II where sulphate is anion, so it comes before NH_3 , so in sulphate is in the coordination sphere. So, we go for the corresponding sulphate name first, so amine sulfato chromium II, during we when we write the formula.

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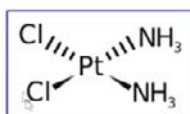
Amminetetraaquachromium(II) sulfate:



Potassium hexacyanoferrate(III):



cisplatin (the penicillin of cancer drugs) is perhaps a proper name because it has been one of the most commonly prescribed as well as a first and successful treatment for many cancer diagnoses.



Diamminedichloroplatinum



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Similarly, aminetetraaquachromium II sulphate is also like this, so amine will come next, water will come first, then potassium hexacyanoferrate, we already we have discussed it. Then will have another molecule which is cisplatin and will discuss in our next class will finish this part the remaining part, that how will name is wonderful molecule which is cisplatin.

And how we name it and how the molecular formula is coming, and how the different geometries will be related to this particular important molecule, so this particular molecule will be named like this, we have two ammonia molecules there. We have dichloroplatinum centre is there that means, 2 amine molecules are there, so it is basically, platinum N H 2 and C l 2 and now the isomeric form some name we are writing as cis.

So, this is some level that where you have, because if we have some alternative positions for the binding of ammonia to platinum centre, and the chloride binding to the platinum centre, we name as a level which is our cis, but the basic compound is diamminedichloroplatinum. So, the (()) this N H 3 groups will come then we have the chloride functions, so we have the molecule like this where we have two of these as in the adjacent position.

So, that is why it is the cis position, when C l P t C l bond is 90 degree which are not in opposite direction, that means C l P t C l bond is not 180 degree, which is a square planer

geometry. If the geometry is in square plane that all 4 platinum bonds, two of them are platinum nitrogen, and two of them are platinum C l. So, if we see that if two of them are 90 degree, when these two positions are occupied by chloride, we call it as a cisplatin. But, in another case when we have C l in the opposite direction that means, they are about 180 degree apart we consider them as trans.

So, these are two nomenclature levels for the isomeric forms, one is the cis form, another is the trans form like we use the nomenclature for ethylene molecule, the ethylene molecule what we have that ethylene molecule can have positions like this. So, even they are opposite, so if we have the dichloroethylenes around this double bond, so around these metal centre we will consider this is the cis and trans positions.

So, when two of them are on the same side we consider them as the cis, so when in this particular case since it is a regular square geometry, when two of them are 90 degree that means, we consider them of on the same side we call it as there corresponding size. That means, if they are C l and if these are two H, we call this as also a corresponding cis molecule where C l is here, and the C l is there on the opposite direction, we call it as a trans.

So, this is a unique molecule when we name this molecule, then we should also correspondingly, name the corresponding geometrical form, and the full name will therefore, be when we have the corresponding compound as cisplatin, will be cis diamminedichloroplatinum. So, next day will continue little bit, and will finish it next day.

Thank you very much.