Hello students,

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Title of the unit: Coordination chemistry.

IUPAC system of nomenclature is the name of the module that we will be discussing today.

So the outline of the module: what we are going to discuss in this module?

Coordination compounds and the IUPAC system of nomenclature for naming, this coordination Compounds.

Learning outcome : Students will be able to identify coordination compounds,

Name the coordination compounds as per the IUPAC system of nomenclature,

Calculate the oxidation state of the central metal ion present in the coordination compound.

So what are coordination compounds?

A compound that results from the combination of two or more stable chemical species and retain its identity in solid as well as dissolve state.

The bond formed in such compounds is known as a coordinate covalent bond.

A water soluble coordination compound almost invariably contains a complex ion.

What is a complex ion?

It is an electrically charged ion, which consists of a central metal atom or ion surrounded by a group of ions or neutral molecules.

So let us see the components of coordination compounds.

So I have given here two coordination compounds on the slide,

We will see what are the components present in this coordination compounds one by one.

The first coordination compound as you can see with the copper as the central metal ion. If you can see the components that are highlighted in blue which are present in the square brackets, that part of the coordination compound is known as a complex ion.

Whereas the other molecule that is present outside the coordination sphere or outside the square

brackets is known as the counter ion.

Similarly, if I consider the second coordination compound which is written at the bottom,

you have potassium as the counter ion and your silver with the cyanide, which is present in the square bracket will be the complex ion.

Now in this case as you can see on the copper and ammonia components that are present in the square

brackets in the first complex, the charge here that is given on the complex is 2 +.

Now this suggests that this particular complex ion is a cationic complex.

Now, if you consider this coordination, compound the charge on the potassium ion is +1

The charge on this complex will be -1, thereby this complex ion will be called as in anionic complex.

There are also some coordination compounds which do not contain a complex ion

they are called as neutral coordination compounds, the neutral molecules for example, $Fe(CO)_5$

Now if you consider this example of a coordination compound in this square brackets we have seen there are two elements present, a silver metal and cyanide which is present.

So what are they?

We will see about the components that are present in this sphere.

So the silver is called as the central metal ion here and the cyanide is called as a ligand.

So any such components present in the coordination compounds there will be a central metal ion

and there will be ligand.

So what is the central metal ion?

Central Ion is a metal or a cation, to which one or more neutral molecules or ions are coordinated.

So in this case you have this as your central metal ion and you have this a molecule which is a ligand which is coordinated to it.

Now, what is a ligand, a ligand is the ion or a neutral molecule attached to the central atom in a coordination compound.So this is your ligand and so these are basically the components present in the square brackets.

Now there are different terms that you need to know when you're learning about the coordination compounds.

So one of the term is coordination number. Now what is a coordination number?

It is the total number of ligands that are directly attached to the central metal.

I will consider the same example here if you can see that silver is your central

metal ion and cyanide is your ligand for the number of ligands that are attached.

So there are two cyanide ions here. So what will be the coordination number here?

It will be 2.
Also there is something called as coordination sphere. What is the coordination sphere?

Coordination sphere consists of central metal atom or central ion and the ligand attached to it Usually in a square brackets.

So this is your central metal ion and these are ligands that are present in the square brackets. So this is called as the coordination sphere you can see here I have highlighted it in the red. This is your coordination sphere.

Now the oxidation state of the metal

Since you have a central metal ion present, you should also know what is the oxidation

state of that particular metal ion present. Now the overall charge on the complex ion is determined by the

oxidation state of the metal and the charges on the ligand and so both together will tell you what is

a charge on this particular overall complex.

Now in this case you have Potassium plus as a counter ion and this is an anionic complex and the charge here is -1.

Now how will you calculate the charge on the silver? That is a central metal ion.

We will see that step by step

So the oxidation state of silver, since we don't know I will put it as X , + 2 x-1 since there

are two cyanide ligands and charge on a cyanide ligand is minus one is equal to minus one, which is the charge on the complex.

So X will be equal to minus one. This minus two will go on the right hand side will become plus two,

so the overall X will get the value of of +1 . + 1 is nothing but the charge on your central metal ion.

This is the way you calculate the charge or the oxidation state.

Now since we have seen the different components of coordination

Compound, different terms involved and how to calculate the oxidation state.

We will now go ahead with the IUPAC system of nomenclature of this coordination compounds.

Now what is IUPAC? IUPAC is International Union of pure and applied chemistry.

Now this Union has made this set of rules in order to name this coordination compounds.
so the coordination compounds are named according to the following rules.

So we will see each rule step by step.

First Rule is order of naming of ions.

So in ionic coordination complex that is the one which are charged,

The Cation is named first, then the anion whereas in the non-ionic coordination

complexes the neutral complexes they are given a one word, meaning

like the one we have seen with the $Fe(CO)_5$.

That complex is a neutral compound, so it will have one word name,

Whereas with the charged ones you need to name the cation 1st and then the remaining part of the complex.

So if I can tell you about this example here your potassium, which is a cation present outside the sphere, that will be named first.

Then the components present inside the coordination sphere.

So then next part is naming the coordination sphere.

So the ligands are named first, then the central metal ion.

As we have seen that in the coordination sphere you have a central metal ion and you also have the ligand.

Now the ligand and will be named first, then the Central metal ion.

Now naming the ligands

There are different types of ligands

Ligands could be neutral, positive or negatively charged,

So there are different ways in which you can name them.

So the names of the negative ligands end in -O,

For example now chloride, which is Cl^-, is a negative ligand.

So when you are naming it, it will be either named as chloro or chloride.

Now Chloro was the earlier form of nomenclature in the new form they are using it as a chlorido

but both are accepted.

Now the name of a positive ligand, which has a positive charge on it will end in -ium that is IUM
Example NO^+ will be named as Nitrosonium.

If the ligands are neutral they will be named as such.

For example, your ethylenediamine is a neutral ligand it will be named as ethylenediamine.

so these are the different formats that are used for naming the ligands based on the charge.

Now these are some common mono dentate ligands, mono dented ligands meaning binding through one atom and their names, the way they are named in the complexes.

So if you have a neutral ligand such as ammonia, it will be named as ammine.

Water will be named as aqua, these are special names that are given for these certain compounds.

Carbon monoxide will be named as carbonyl. Pyridine will be named pyridine itself.

Now there are negative ligands so the charge on these is minus one (-1),

so they will be named as , If azide is the ligand N_3^{-1} ,

then we have seen that the negative ligand and the name ends with –o ,they could be either azido or azo

Similarly, a bromide would be bromide or bromo and so on.

So such negative ligands are listed.

These are some common bidented ligands meaning they are binding through two atoms.

So this neutral ligands like pyridine , ethylene diamine they will be named as such,

whereas a negatively charged ligands will end with. -o that is,

a carbonate will be named as carbonato, oxalate will be oxalato.

There are some exceptions in naming neutral ligands, of which we had already seen in

the one of the previous slides that water will be named as aqua

NO will be named as nitrosyl , CO will be written as carbonyl and NH_3 will be written as ammine

These are special names for this neutral ligands in the coordination compounds.

Now numerical prefixes to indicate the ligands

That is, if more than one of that particular type of ligand is present.

Suppose there are two water molecules. We will not just write aqua, since there are two so you

will give some prefixes to them. Two meaning it will be written as a diaqua

so such numerical prefixes indicate the number of that

particular ligands and prefixes. Di Tri, Tetra, penta, hexa, etc are used to indicate the

number of ligands of 1 type.

so one such example is given here wherein if you can see

this complex compound, you have six cyanide ligands and

so this six cyanide ligands While naming will be named as

Hexa Cyano because there are six so it will be named as hexacyano

now if the Ligand have complex names such as ethylene diamine ,triphenylphosphine etc

which themselves contain the prefixes like like di, tri in their name

itself then their numbers 2, 3, 4 are indicated by prefixes such as

bis ,tris or *tetrakis* because they already have the di or tri in their name itself.

So in order to number how many are present, you are using the prefixes like *bis, tris* and *tetrakis.*

For example there is another coordination compound which is given here in that a simple ligand

chloride is also present and ethylenediamine is present.

Herev there are two chloride ligands present, so they will be named as dichloro,

whereas ethylenediamine already has a di in its name and there are two ethylenediamine so you

will not write it as di di ethylene diamine but you will write it as *bis* ethylenediamine and your

ethylenediamine will come in brackets.

Order of naming the ligands.

Now if there are more than one ligands, which name of the ligand will you write first? that will be the confusion.

So Ligands are named in alphabetical order irrespective of their charge.

So whether ligand is neutral whether it is positively charged or whether it is negatively charged as per the alphabetical Order they will be named.

for example in this coordination compound there are two ligands that is chloride and ethylenediamine.

So chlorine and ethylene diamine are

the two ligands , the following alphabetical order will be followed,

wherein you know that C comes first before E in the alphabetical order.

So the chlorine ligand and will be named first as dichloro since there are two then the ethylenediamine which will be named as *bis* ethylenediamine.

Now the prefixes like di , tri ,Tetra, Or *bis* that indicate the

number of ligands are not considered for alphabetical order.

So you cannot say that the D will be considered for the alphabetical order, No.

Only the names, the first alphabet of the ligand will be considered for the

alphabetical order and not its prefixes.

Now ending of the names.

Now when a complex is anionic, the name of the central metal atom ends in -ate.

We have seen different complexes, If cationic complexes or anionic complexes.

there are different ways of ending central metal ion name at the end.

So if it's an anionic it will end in –ate.

So if this is a complex the counter ion potassium which is positively charged,

so the charge on the complex is-1 which suggests that it is anionic complex,

so it will be named as per the rules:

From the 1st that your cation outside

the coordination sphere will be named first, that is potassium, then the ligands as per the alphabetical order, ammine a comes first, so ammine then pentachloro.

Since there are five chloride ligands so pentachloro palatinate, it is not written as platinum but it is written as palatinate because it's an anionic complex so the name of the central metal ion will be will be ending in –ate and then the oxidation state of the central metal ion will be written in the Roman numbers in the parenthesis.

You also have to remember that the name of the components present in the coordination sphere are written without any space.

Now there is also a note for you all for anionic complexes the Latin names of the metals are commonly used, for example, a copper will be given, if present in an anionic complex It will end is Cuperate ,

Iron It will be Ferrate, it will be not iron on the Latin name so it will be ferrate.

similarly silver Argentate , Ti will be Stannate, Gold will be Aurate etc. so that you need to remember.

For a cationic complex and neutral complexes, the name of the metal is given without any characteristic ending the way we have ended with - ate for anionic complex we are not using any characteristic ending for a cationic complex.

Now for example, this is a cationic complex, here since SO_4 is 2-,

there will be positive charge on the complex, it will be cationic complex.

So while naming it, It will be hexaaquairon(II) since 6 ligands are there, you know water is named as aqua a special name is given.

Iron , here iron is not written as ferrate it is written is just iron because the complex is a cationic complex.

If it was anionic complex it would have been written as ferrate.

But it is cationic complex so it is iron with the oxidation state in the Roman numbers in the parenthesis and then your counter ion

Now the counter ion.

Also you need to remember whether there are one sulfate or two sulfate you are only writing as it is sulfate. Counter ions are not given prefixes as di or tri.

oxidation state of the central ion

Oxidation state of the central ion is designated by Roman numbers such as I,II,III,IV,V in the

parenthesis at the end of the name of the complex without a space between them.

So if this is a complex, if you can see the oxidation state of the platinum is written

in the Roman number as IV, so you start by the name of the cation outside the coordination sphere.

Potassium amminepentachloropalatinate(IV)

Since it's an anionic complex it ends in -ate with oxidation state IV , how to calculate the oxidation state we have already seen.

Now there are also certain coordination compounds in which the bridging ligands are present.

So if the bridging ligands are present between the two metal ions then those

bridging ligands you give them the new letter as the prefix, so the prefix μ is repeated before

the name of each kind of bridging ligands

So if this is your coordination compound, there are two bridging ligands amine and Nitro.

So it will be written as μ-amido-μ NitritoN because it is binding through

nitrogen and then the name octammine because there are 4 + 4

total 8, dicobalt ,2 cobalt and the oxidation state in the bracket as(III) and nitrate

This is another coordination compound with bridging ligands

There are two hydroxyl groups,

so it will be di-μ-hydroxo-octaaquadiiron(III) sulfate. Now the point of attachment if a ligand can

coordinate through more than one atom, then the point of attachment of the ligand is indicated by putting the symbol of the atom, coordinating as we have seen in the previous slide. So if Nitro is a ligand if it's

coordinating through nitrogen, it will be nitrato -N

If it's coordinating through oxygen it will be nitrato -O

As for the earlier nomenclature, it would be Nitro or Nitrito.

so these are examples of the ligands which can coordinate through different atoms.

So again, Nitro is a ligand here, so it is triamminenitrato-N coordinating through nitrogen cobalt(III),

whereas in this case it is coordinating through oxygen,

so it is pentaamminenitrato-Ocobalt(III)sulfate, coordinating through oxygen.

Similarly another example is thyocyanato which can coordinate through S.

if it's coordinating through nitrogen, It will be thiocyanato-N as per earlier

nomenclature it is thiocyano or isothiocyano.

So these are few examples wherein we can try naming the coordination compounds following the rules.

So anionic complex:

It will be named as Potassiumtrioxalatoalumminiate(III)

Cationic complex Diamminesilver(I) chloride

and a neutral complex pentacarbonyliron(0).

These are the references.