Industrial Inorganic Chemistry
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Lecture – 10
Nitric Acid, Ostwald Process and Uses

Welcome back to this class where we are talking about the corresponding nitrogen compounds and just now we have seen that how we can produce hydroxyl amine. And now we will see another very important industrially important compound is the production of H N O 3.

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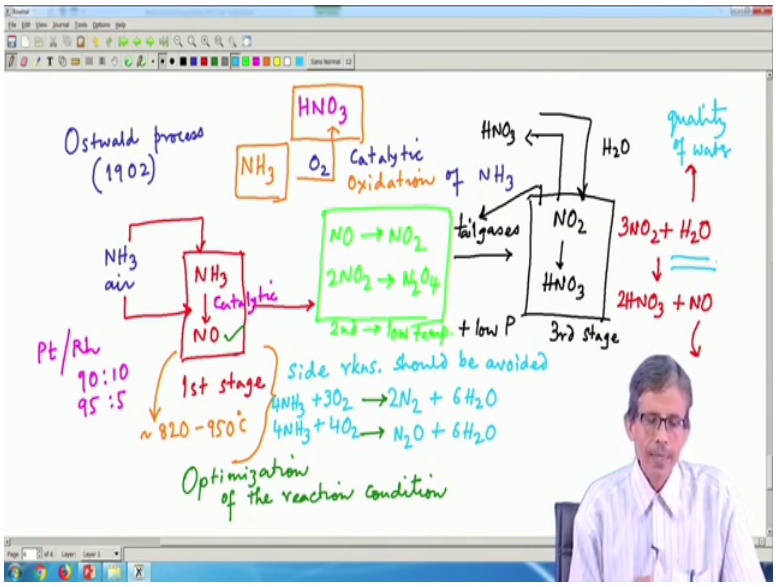

So, the production of nitric acid; as we have already seen that how we can convert your N H 3 to N O, that means nitric oxide formation and that nitric oxide formation is useful for giving you your hydroxyl amine formation. So, what we will see now that this particular nitric acid production this will be dependent on so many things. And one of the thing that we can consider is the corresponding readily available or cheaply available ammonia if we can think of.

So, how we can convert this ammonia to nitric acid is simply the oxidation. And as we have seen that this particular oxidation can give us to that corresponding nitric oxide. And if we are able to oxidize this nitric oxide for get some other nitrous gases that we will see and those nitrous gases, if they can trap water molecule, we will get nitric acid;

so, this oxidation, so it can be again a catalytic oxidation. So, catalytic oxidation of ammonia will give rise to the corresponding production of your nitric acid. And this is our typical well-known Ostwald process, which has been discovered a long back during 1902. So, this particular Ostwald process will be dependent on the availability of ammonia. So, we will have ammonia and simple air not any other thing that will O 2 present in air.

So, if we go for the catalytic oxidation of these, so O 2 present in air will be very much useful, and that O 2 present in air can be utilized for this particular oxidation, where your ammonia will give rise to the production of N O. So, we can have this ammonia plus N O at in one hand. So, this particular reaction chambers if we can have two of these reaction ports basically where ammonia can enter through one path, air can enter through this particular path.

So, this is the corresponding first stage of reaction, first stage of reaction, and we can go further. And in this particular point what we can see that how we can go for this not only the chemistry wise, but also the chemical engineering wise that means how we can design the corresponding reactor, how the gasses will enter, how the mass transfer, how the heat transfer can take place, all these things, but we will not go for all these engineering aspects.

Because the basic chemistrical aspects or the chemistry aspects we will follow, we can utilize their calculations, we can utilize their data for all these things. So, the first stage of oxidation basically tells us that we should use a catalyst then so is the catalytic one. So, catalytic oxidation, as we all know there are large number of catalytic oxidation, but not all of them are industrially important, industrially useful, industrially feasible. So, choice of this catalyst will again be very useful and we are talking about so many these things about this catalyst, the choice of this catalyst.

So, when we consider in this particular case that means for this Ostwald process not only platinum, but along with platinum another noble metal rhodium. We use Rh the rhodium and which is basically some alloyed one 90 is to 10 or sometime 95 is to 5 mole ratio of these two metal metals basically or elements can give rise to a very good and very effective catalyst for this particular conversion. And this particular catalytic conversion tells us that it can also optimize the temperature of the reaction.

And the optimization of the temperature tells us that around 820 to 950 degree centigrade of temperature is very much useful for this particular conversion. So, we know about the catalyst, we know about the temperature, because we have to produce that particular amount of energy we have to explain for getting this high temperature reaction so it is basically a high temperature catalytic conversion reaction.

So, all these things basically what we are utilizing and along with that we should always be considered about its corresponding side reactions. So, if we just consider, because the chemical engineers will also be bothered about the corresponding utilization of these thing and the corresponding involvement of this particular reaction, because if your catalyst is not so effective its temperature is not as optimized at this temperature.

And also the typical catalyst making also that the quality of the catalyst, the purity of the catalyst, whether it is typically 90 is to 10 or 95 is to 5 or different that will also tell us how good this particular conversion, how useful this particular reaction is and we have to minimize the side reactions. So, we should have some good idea about what are those side reactions.

Side reactions are that those reactions, which can also take place in a similar condition of little bit different conditions for these that means if you go for the corresponding oxidation of ammonia, we will get some other products also. What are those product one such product is your typically the dinitrogen. As we all know that ammonia is produced from the reduction of dinitrogen. So, when the reverse process that means, when we try to oxidize the ammonia, definitely it will give you the dinitrogen back.

And also the other oxidized form that means, the nitrous oxide so the formation of these two things that means these two molecules should be avoided for this particular reaction. So, optimization of the reaction condition, so optimization of the reaction condition is therefore very much important, otherwise we will end up with the production of N 2 and N 2 O along with your desired N O. So, this particular one we get the reaction basically how we get those reactions, because these reactions are 4 N H 3 plus 3 O 2 giving you twice of N O plus 6 water, similarly 4 of your N H 3 plus 4 of O 2 giving you N 2 O plus 6 H 2 O.

So, side reactions should be avoided. So, these things, therefore tells us that from stage one we can proceed to the stage two where we can go for oxidation of N O 2 N O 2 or

this 2 of these N O 2 can dimerize to give you N 2 O 4 we all know that N O 2 can be dimerized very quickly to giving you N 2 O 4. So, this is your second stage of reaction. So, this second reaction or the second stage of reaction is favored only at low temperature that means, we should monitor this particular reaction at a low temperature.

So, this low temperature reaction is also favored not only low temperature, but also low pressure. So, low temperature and low pressure reaction, because you should not be bothered about the amount of this N 2 O 4 formation will be happy with N O 2 formation, because N O 2 is also by trapping water molecule can give you the corresponding nitric acid to you. So, the formation of this N O 2, and N O, N 2 O 4 is useful for us to go from second to the third stage. And at this particular point either N O 2 or N 2 O 4 from trapping of water molecule giving you H N O 3.

So, this is the third and final step of the reaction for the production of your nitric acid. So, this is the third stage of reaction, where we introduce to this reaction chamber or the reactor we call water and at one point through one point rather, we get nitric acid. And also sometime we find that we will get some gases also which are known as tail gases. So, what are those tail gases tail gases are nothing but since we are handling something, where the gaseous product that means, N O 2 or N 2 O 4 being utilized for the formation of nitric acid.

So, the gas which are not getting converted quickly or immediately to your nitric acid are still there that means that all nitrous gases not only your N O 2, but N O can also be there, because N O is your starting compound. So, N O, and N O 2, and N 2 O 4, the mixture of all these gases can be there and those should be there so nitrous gases will be through your nitric acid the form nitric acid can be contaminated with that of our tail gases. So, we have to purify this nitric acid from your tail gases. So, the purification process is therefore, is a very important step of these reactions.

So, this particular case what we will see now that this particular reaction, what is happening is that 3 of your N O 2 is reacting with H 2 O forming 2 moles of your nitric acid and 1 N O back, which can be recycled back to this particular step. So, from the production side basically the purification of the tail gas and taking that tail gas again to the starting chamber. As well as the N O, what is forming as a byproduct for this particular reaction, because it is not that all N O 2 will be utilizing, because this

corresponding the action. Thus N O 2 and this particular water reaction giving you is the corresponding nitrite ion, the nitrite ion is there in this particular nitric acid.

So, N O will be recycled back and this particular water is very important thing at this particular point that the quality of the water, the purity of the water, we should remember at this point that how we can utilize this particular water. So, is not that any water we can use as we have seen from our very at the very beginning that water can also be very useful industrial material for industrial in organic chemistry classes.

So, now, we see that how useful this particular water is for the production of nitric acid. So, if we are preparing something. which can also be a laboratory reagent, laboratory type of reagent, lr type of reagent, or guaranteed reagent, g r type of reagent, or analytical type of reagent, air reagent. You should have also this water molecule available for this reaction should be analytically pure, or a guaranteed water sample, or a typical laboratory reagent type of water molecule for this particular purpose. So, these particular schematic things and all these things will tell us that how we can utilize, the formation or the production of this nitric acid.

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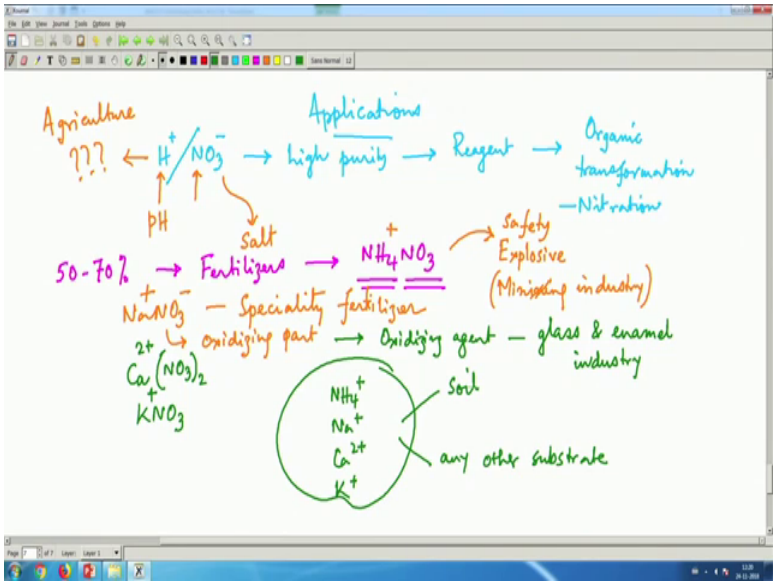

Now, we will just quickly summarize this as the corresponding applications. What are those applications we can have for these nitric acids, because it is a very useful in organic acid in the we call it as the mineral acid. So, one such is that how we can get that these we can have N O 3 minus.

So, supply of this N O 3 minus and supply of this H plus also, because the high purity of this nitric acid can be useful as a very good reagent laboratory reagent, definitely it should be guaranteed one also for all different types of organic transformations or any other thing, where we can go for nitration. Nitration reaction that means, the introduction of the nitrate group in the benzene ring, or any other complex molecule even for the production of the drug molecules, or the production of the pharmaceutical molecules, or the nitrates can also be very much useful for different industrial processes. So, one such typical example is for the nitration process.

So, this nitration process along with this so not only these, but these as its corresponding application in agricultural industry or say agricultural chemistry so, in agriculture. So, what we use there, because this we all know that nitrate is the corresponding micronutrient for the plants, for the trees. Similarly, this is also can be useful for the adjustment of the PH. So, we cannot directly use this as the corresponding supplement for your soil, we have to go for transformation of these to any salt. So, the nitric acid based salt production will be very useful for this particular purpose. So, about a large amount that means whatever amount we produce in industry 50 to 70 percent basically of that production of that nitric acid is being utilized in making fertilizers, in making fertilizers.

So, what is that fertilizer the most important one fertilizer would be therefore, your ammonium salt, because this part the cationic part is the reducing one and the anionic one the nitrate one is the oxidizing agent so they can go for all sorts of reactions. So, this ammonium ion as well as the nitrate ion can give you the incorporation of nitrogen in as a corresponding food material for the plant. So, this particular one can give you as the corresponding one, because this one is giving is a corresponding as a fertilizer one. So, this particular nitrate can also be useful along with your ammonium ion as a typical explosive, because it is explosive in nature your heat of reaction and heat of temperature is very high, when they export that means this anionic part which is oxidizing in nature is try to oxidize your the corresponding ammoniums side.

But it can be utilized in a controlled one. So, it can be your safe explosive or safety explosive. So, safety explosive for the mining industry for the mining industry for if we go for some breaking up some hill or breaking up some undergrounds area so mining, so, mining industry. So, this particular one can be useful in that particular case that it can go

for explosion in terms of its corresponding useful purpose not for making any other thing, which we all know that making r d x and all other thing which is harmful for in terms of its explosion can also utilize ammonium nitrate.

So, this ammonium nitrate can give rise to also the production of similar salt that means your sodium nitrate, when nitric acid can react with sodium bicarbonate, sodium carbonate, or a very dilute solution of sodium hydroxide. So, this particular one, where the soil also needs along with your ammonium ion if it also needs corresponding sodium ion, so is a speciality fertilizer, is a speciality where we also supply sodium ion along with your nitrogen requirement for the soil. So, this is there and also this nitrate part which is a oxidizing one, it is your oxidizing part, these oxidizing part can be utilized for the oxidation agent. So, it can be a very good oxidizing, is a very good oxidizing agent in the industry, which is devoted to glass making and enamel making. So, in glass and enamel industry, these are utilized as a typical oxidizing agent.

Similarly, also we can make some other salts like that of your corresponding calcium salts, because calcium also is a typical requirement for the soil. So, we can utilize it as a corresponding calcium nitrate salt or the corresponding making of potassium nitrate salt, because these we are changing from ammonium ion to sodium ion, and sodium ion to calcium ion, calcium ion to potassium ion.

So, these metal ions the different metal ions or the metal ion like ions like ammonium, sodium, calcium so these can be a useful one with supplying all these ions to soil or to any other substrate like that of we can utilize as a oxidizing agent for the making glass, and enamel. And sometimes this particular one can also be trapped inside the glass material or the enamel material. So, we should also be careful and also be choosy, also be selective for taking those things, where you can have the corresponding use of the sodium that means, when we make the sodium soda glass or sometime potassium is also trapped in the inside these glasses.

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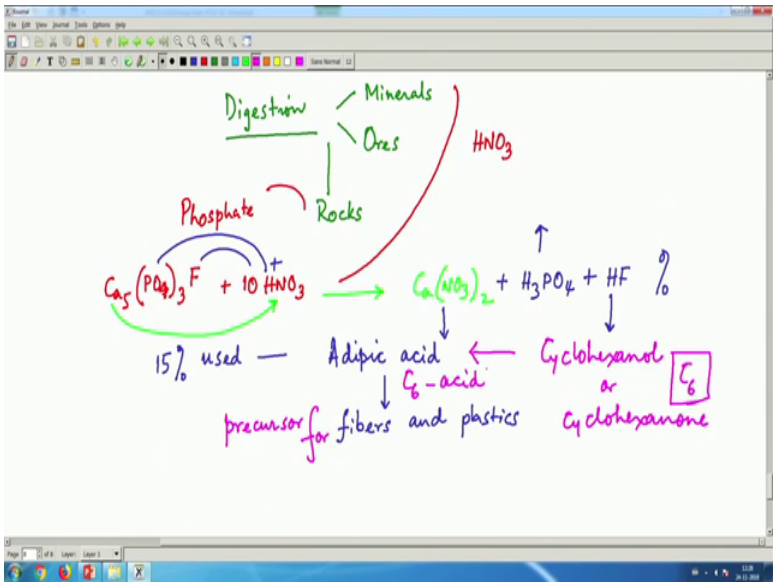

So, this particular one can also we can see, when we go for other aspect of the nitric acid. The application of these nitric acid for some acid which we call as the for digestion purpose, where we utilize these digestion we all know that we can have the different minerals, ores and one such material we can utilize as the rock material. So, minerals, ores and rocks can be attacked by H N O 3, because this H N O 3 we all know that is oxidizing as well as is supplying H plus that means if we can utilize this H plus that means, the controlling the corresponding acidity of the medium, can give rise to some other reactions such that you can go for the corresponding leaching of some useful minerals, useful metal ions, or useful species from that particular medium.

So, if we can handle this particular rock, and if that particular one is the phosphate rock, what happens, how nitric acid can be useful for attacking your phosphate rocks or the phosphate is your ingredient in those rocks. So, one such example for that rocks is calcium 5, C a 5, P O 4 whole 3 F, C a 5, P O 4 whole 3 F the flora phosphate, calcium phosphate, which is being attacked by nitric acid. And that nitric acid is utilized in a nicer way to release this calcium.

So, this calcium will come and bind that means, otherwise is a very, is a very useful and very hard one and a solid one. And its entity is only in the solid state and that particular entity that we can get is for is typical entity for stabilizing this as the corresponding phosphate as the anion and fluoride as the anion. Because slowly we are moving

towards, the other inorganic element what we will be talking about in our next class is the corresponding phosphorous compound or the phosphates. So, if we can have this calcium can be very nicely be taken care of by your nitrite, nitrate ions. So, we will end up at that particular point with that of your production of your calcium nitrate.

So, we will produce calcium nitrate from there so this calcium nitrate along with this; that means, your phosphate will be taken by your H plus so forming your H 3 P O 4. So, use point by point; that means, the cation is utilizing for some purpose anion is also utilizing for some purpose such that we can break the corresponding phosphate rock, definitely is not a full form of the rock the whole solid you cannot use, it should be pulverized it should be powder. So, you can grind it get the powder and that powder even if you in a typical laboratory in a chemistry laboratory, inorganic chemistry laboratory, if you go analytical chemistry laboratory, if you go and if you take the powder and put drop by drop that particular acid of required concentration.

Sometimes it so happened that you can use a high concentration that means, the concentrated nitric acid can only attack the rock. And sometimes some elevated temperature can also be utilized that means high temperature reaction can give rise this particular reaction. So, basically what we are getting we are getting a very simple salt of calcium from out of that rock. So, we are producing calcium nitrate if your rock is a very cheaply available to you so is we know that is a very naturally available rock we can have so that naturally available rock can be attacked by simple acid.

So, it is basically nothing is the acid digestion or acid fusion sometime we can call. So, this particular one can give you a calcium nitrate which is a very useful compound also. So, this calcium nitrate production along with some amount of phosphoric acid we will produce as well as some other thing also we will produce, because we can take care of this fluoride also by this protons of H plus.

So, hydrofluoric acid can also be produced so this production of this hydrofluoric acid only thing that how we can separate this, how we can separate this and how we can separate this, H F from this particular reaction medium, because H F we all know is the gaseous product so it can be taken away if we go for a high temperature reaction of this, so at elevated temperature H F can go out from these thing and basically we are taking away that fluoride content.

So, this is a fluorophosphate basically. So, the fluoride content of this can also be analyzed by knowing the percentage of H F formation from this particular reaction. So, we see that many application of this nitric acid from a very simple reaction of your typical attack of your mineral or ore by that particular acid to get that. Then a very small amount that means only a 15 percent of the total production, what we produce what we get from the industry. So, 15 percent of the produced one is used for making one important industrially important compound is in making adipic acid as we are talking in some previous time that we are talking about this thing as for making of nylon, making of fibres and plastics.

So, making of fiber making of plastics and making of all these things are dependent, because adipic acid is the precursor for fibers and plastics. And the production of these particular adipic acid is dependent on your nitric acid. So, nitric acid should be your chip or the main constituent for the particular production of adipic acid which is nothing but a typical one from oxidation of your cyclohexanol or cyclohexanone. So, cyclohexanol or cyclohexanone which is a basically a C 6 compound and that C 6 compound is also converted to a C 6 acid which is a adipic acid. So, nitric acid will be utilized for your oxidation is a ring compound cyclohexanol or cyclohexanone is a typical organic ring compound.

And that ring compound we have to cut. So, at one particular point if we cut, it, it, it gives you a linear compound and linear compound with two ends which has been broken or which we have cut along with that your c-c bond. So, those two bonds basically in presence of nitric acid can be functionalized, we initially get two of these as the aldehyde that means, both the two ends will be CHO-CHO and further oxidation of those two ends will give you two carboxy acids or the two carboxy functions those are basically giving you the corresponding (Refer Time: 30:40), which are nothing but your adipic acid.

So, the question therefore lies on you that if I ask you that how your nylon production, or the production of fibers, and plastics are dependent on the availability, or the cheap availability, or readily or readily availability of your nitric acid in industry ok. So, that we should be very much aware of the thing that the amount of nitric acid and the availability of your both these two starting materials definitely the cyclohexanol and cyclohexanone is dependent on the production of large amount of your adipic acid ok.

Thank you very much.