Industrial Inorganic Chemistry
Prof. Debashis Ray
Department of Chemistry
Indian Institute of Technology, Kharagpur

Lecture – 29
Hydrochloric Acid Manufacture

Hello, good morning everybody. So, we will just continue once again with the halogens and the different halogen based compounds, which are industrially important. And after fluorine, we were with the chlorine and the chlorine based compound. So, the what we have seen earlier that how we can get chlorine out of the natural resources, because all these cases whatever we are discussing is based on the huge amount of natural resources, particularly the sea water what we are now looking at where you can have the huge source of NaCl and the other halides.

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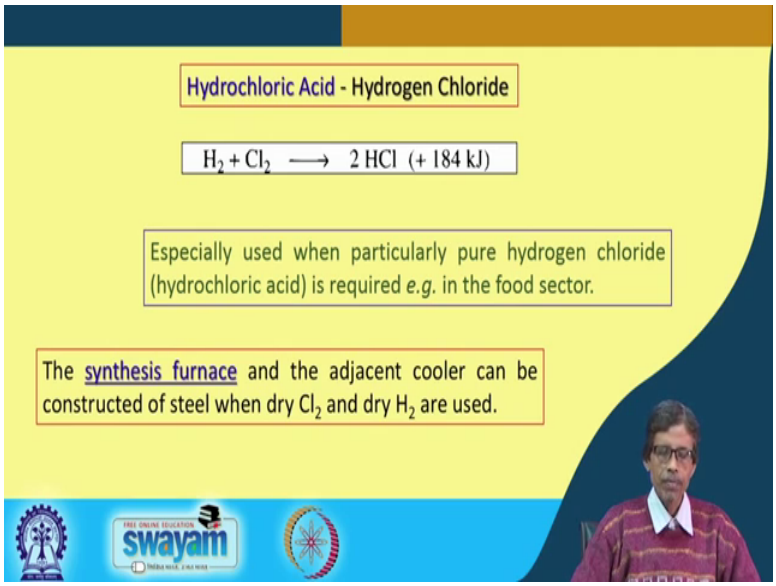

So, after chlorine, getting the chlorine itself that is the CL 2 molecule itself. Now, we can see how we can use like your sulphuric acid or nitric acid one more important mineral acid as we know is your hydrochloric acid and the corresponding hydrogen chloride, which can be considered as the hydrogen chloride gas. So, how we can produce very efficiently these two species, because these two are very important compounds.

If we have the corresponding aqua solution of hydrochloric acid, concentrated solution, and the dilute or 1 is to 1 hydrochloric acid solution; starting from the laboratory use to

the industrial processing and the utilization. Similarly, the HCl gas also sometimes it is also very much useful that if we can do some reactions or some conversions or some process development or the process making thing, by utilization of the simple hydrogen chloride gas itself.

So, how we can get these two? So, it is a very simple reaction is a very simple exothermic reaction, which generates heat from the reaction medium is the combination of two gaseous thing one is the hydrogen, another is the chlorine. So, combination of these two gases, as we have already seen earlier the processing of water molecules that means, the huge source of water.

Now, we are considering the source of chlorine from sodium chloride or the brine water or the sea water. So, we get chlorine from there as well as we have the regular supply of water. And water we as we have seen that one of the processes of getting hydrogen gas from water is your typically the electrolytic process or the electrolysis. So, if we can have some ancillary industrial processes, which can supply in a regular basis that both these two gaseous components one is H 2, and another is Cl 2. So, we will be able to combine them. So, the reaction as on the pen and paper case that we can write it down like this, so is fusible also. And the amount of heat liberated from the reaction is also is corresponding exothermicity of the reaction it also tells.

So, when we require basically, particularly the pure hydrogen chloride or the hydrochloric acid gas, because the purity is always very important. As we all know the different grades of materials we know and starting from the typical laboratory get reagent the LR reagent LR type of reagents to the guaranteed reagents or the analytical reagents, so we know that is also a very expensive procedure for getting the higher purity of the material.

So, if we can have some arrangement, where in house we can make the corresponding hydrochloric acid or the hydrogen chloride gas itself. If we are going to use that particular material in the food sector, so you should be very much careful that it should not be contaminated with any other things. So, is best way of getting this is that either in C 2 or some arrangement for the combination of these two gaseous components is that you make highest possible purity, which can be directly used for the food industry.

So, if you want to use it in the food sector, so this is the corresponding procedure where we can utilize it for the production of your hydrochloric acid. So, what we can have as we all the cases we know that whatever molecule the new molecule or the new species, we are producing or the new material we are making. We have to go for a particular synthetic procedure.

So, we do the synthesis, and since the reaction as we know that is the corresponding amount of energy per mole is liberating as in the equation or the chemical equation is a 184 kilo joule per mole what is being liberated, so that will basically heat up also the arrangements, since the exothermic nature of this particular reaction.

So, the furnace what will be used for this particular synthesis should have a cooling arrangement. So, it can have a adjacent cooler, which can be constructed out of some very top material, which is steel and which is not being corroded by the starting material as well as the product of this particular reaction that means chlorine, we all know is a very corrosive material or the corrosive gas which can corrode iron or any other soft material, which is not hard enough or inert enough.

But, if we can go for a particular steel furnace, it will not be able to react with that particular steel surface, and it is basically inactive with the chlorine gas as well as the corresponding material, what is being produced over the at the corresponding HCl or in the form of it is aquas form when it is getting moisture that means, the moisten one or through some absorption, tower of water like that of your making of sulphuric acid, when sulphur trioxide is getting absorbed in absorption tower of water.

Similarly, this particular case also the produced hydrogen chloride gas can absorb water, and produces the corresponding aqua solution of hydrochloric acid depending upon its corresponding concentration of the gas and the amount of absorption. We get the different varieties or different concentrated solutions of this.

So, we have to have the dry HCl and the dry hydrogen gases, because it should not be moisten that is the production of this reaction that means, the combination of these two gases which is producing us the corresponding HCl, and that HCl should also be dry. Because, sometimes we have if we have some doubt in it that the gas produced over there has some moisture, we should try to avoid that moisture also. So, it must have some drying column or the moisture trap in between from the outgoing gas, what is living the

furnace that synthesis furnace. It should pass through the different columns, which can absorb the moisture and which can take out that particular amount of moisture from all these cases.

And the corresponding reaction stoichiometric will also tell us that the produced HCl should not have the starting material or that means, these two initial gases what we are using for these reaction that means, it should not have the H 2 as well as C L 2 in it. So, the amount what is being produce, so you should have also not only the trap or the moisture or the water or the water vapour in it. If sometime it can come, you can also some trap for the unreacted CL 2 or unreacted H 2 which can also be going out along with the hydrogen chloride gas, which is being produced from this reaction.

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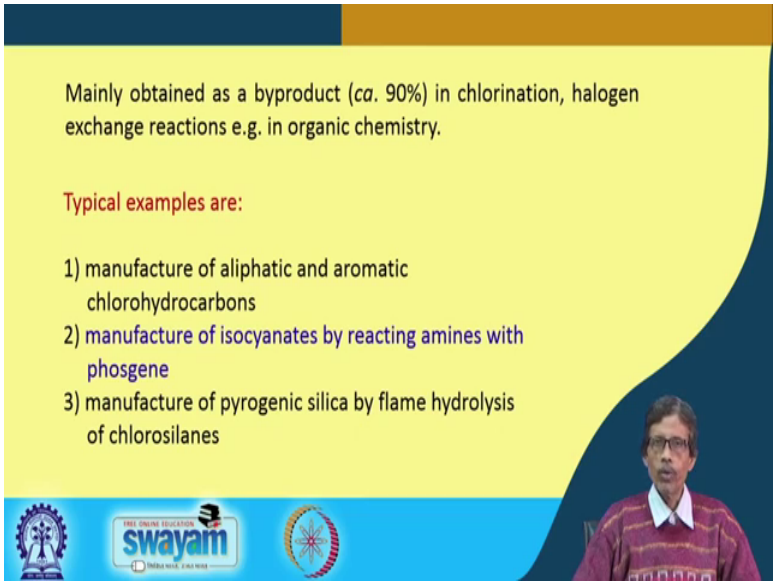

So, is sometimes it is also obtained as a byproduct. So, if we consider that any kind of reaction, we all know that if we are able to remove some chloride from some organic molecule or some other group that mean the CCL bond is being broken or being reduced with that of your hydrogen gas or hydrogen on some kinetic surface like that of your palladium charcoal or anything.

So, one of the product for that particular reaction is your typical HCl, similarly it can be a byproduct for different other chlorination reaction or the halogen reactions in organic chemistry. So, what are those examples basically, what we can have in our hand where we get HCl as the byproduct. So, if we are concentrated our attention for the material

that is the target molecule, what we are making a through this particular organic transformation like that of your simple chlorination or the chlorine exchange reactions.

We should also take care of the thing, because if the HCl produced is in the gaseous form. So, we should take out that that is over the reaction medium, if the other material, if it is pharmaceutically important or it is a dye molecule. So, over the reaction medium we should have the gas molecules which is covering the reaction medium, the liquid reaction medium. So, we should have the corresponding exit pathway above the liquid such that we can take out the byproduct as HCl from that particular outlet.

So, we should have the typical provision of making that particular outlet, which can take out the HCl, which is being produced from there as a byproduct of any kind of reaction. So, first of these category which can be consider as a typical example for this byproduct chemistry or the byproduct isolation as HCl is the manufacture of aliphatic and aromatic chlorohydrocarbons.

So, if we can go for chlorohydrocarbons that means, we know that hydrocarbons are C N H 2 N plus 2 type of thing that we can have carbon as well as some hydrogen atoms attached to that particular carbon centre. Then if we are able to substitute that means, some of the CH group or the CH functions can be substituted by CCL function that is if we have the methane which is CH 4, if we substitute only one of the CH bond of the methane by CCL, we get that is with the chloro methane or methyl chloride. So, during that particular procedure of making the methyl chloride out of methane, because methane we know is a availability is plenty starting from your natural resources, like that way of your natural gases.

So, if we are able to make it from that particular case that if we are able to make this particular reaction with chlorine, so chlorine will react with that particular one as your corresponding chlorination of the molecule as well as it will take out that hydrogen as H plus and chlorine will give you the CL minus producing your HCl, so that way you can justify also the production of HCl from that particular reaction.

So, if we have a corresponding chlorination reaction for hydrocarbons in industrial scale, so huge amount of that material we are trying to produce and that particular case we should not ignore the production of HCl. Because, HCl is a gas, it can come out from the reaction medium, the reactor medium or the reactor huge reactor. So, the gas will just

come, and if we are not able to take care of that particular gas which is basically a valuable product, valuable byproduct from the reaction medium.

If we are not able to track that particular one, we will just simply throw away in to the environment, so it will just pollute the environment. So, there should be a very serious environmental concern out of that. So, if we are very much capable of tracking that particular amount of production of HCl from that byproduct reaction, we should be able to trap the entire amount of HCl, what is being produced from that particular reaction. So, there is no need to produce separately HCl for some other industry or for the same industry, while we are going for the chlorination reaction, but we can have some arrangement such that we can trap the product of HCl.

Similarly, during the manufacture of isocyanates we all know that the typical organic isocyanates the SCN group having the SCN group by reacting amine with phosgene. So, is a very simple reaction where we get the cyanates, cyanates is nothing but either a functional group of CNO or OCN that OCN the part what is being attached to the alkyl function R, we get the isocyanates, how we get that? We start from the amine that means, it is a molecule having the amine function NH 2 function attached to the carbon and the hydrogen based molecule.

So, on that we are trying to put CNO such that you get a function or the functional group, which is utilized for the conversion of your NH 2 to NCO such that you get the corresponding isocyanate molecule out direct out of directly from the amine itself. The most reactive species for that particular one is your phosgene. Phosgene is also a gas which is CO CL 2 nothing but you have the CO the carbonyl function like your carbon monoxide, and that carbon is attached to two other CL functions.

So, when it reacts with the phosgene reactivity thing, the reaction is such a; we are given you that particular reaction that it is only reacting with the amine function. And that amine function is also giving out two of its hydrogen from NH2, it is a primary amine one. So, the primary amine function having a NH terminal NH 2 group is giving two of these hydrogen atoms to the phosgene molecule.

And taking up the CO part of the phosgene molecule inside it making that N to NCO that means, the alkyl or the other type of substituted isocyanides. And by that time it is producing the double amount of H plus CL combined thing that mean the hydrogen

chloride that means, double of these it can produce, because we do not need any cause of chlorination reaction, where chlorine is being inserted into the molecule itself.

But, here we are taking away all the chlorine from the phosgene molecules such that taking the hydrogen atom from the amine function, it will produce double amount of HCl. So, now HCl in a greater amount is again a byproduct for the reaction, and we should take care of that particular product. And we can store it, we can purify it, and we can preserve it for further use.

Similarly, manufacture of another pyrogenic silica is a special verity of silica pyrogenic which is heat sensitive also by flame hydrolysis of chlorosilanes. We all know that is the chlorosilane Si H 4 is the silicon hydride, where all the 4 hydrogen atoms are attached to the silicon, and if any one of them like your methyl chloride or chloromethane, now carbon can be replaced by silicon only. So, it will be S H 3 C L like your CH 3 CL.

So, chlorosilanes can also be treated for producing silica itself that means the silica as in the elemental form. So, when it is producing in the elemental form and the chlorosilane itself has different varieties of chlorosilane we can have. You can have 1 chlorine attached to the silicon, 2 chlorine can be attached to the silicon center or 3 chlorine centers can be attached to the silicon center.

So, during that particular processing that means, the making of silica itself that means, silicon dioxide, silica pyrogenic silica or the silicon itself the elemental form also in all these cases you have to remove the corresponding hydrogen attached to the silicon center or the chlorine attached to the silicon center. And these two can combined further to produce you the hydrogen chloride once again as your byproduct molecule from the industrial scale of making this pyrogenic silica out of chlorosilanes.

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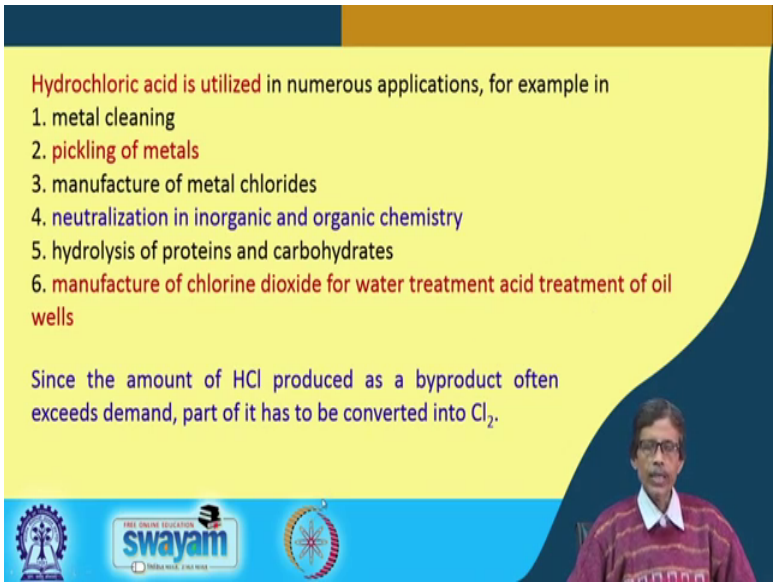

Hydrochloric acid utilization if we now consider that what are the areas where we can utilize this hydrochloric acid, because why we need the manufacturing of hydrochloric acid in the industrial scale.

The reaction is a very simple one only thing that how big reactor you can use, and what are the other conditions you can optimize in terms of your chemical engineering aspects, you can also standardize the all these thing. But we are basically interested to know now how we can utilize, because without utilization you cannot produce that much amount of hydrochloric acid or hydrogen chloride for giving you a new chemical in the industrial scale.

So, first of these is your cleaning of the metal surface. So, if we all know that the surface, when if it is a iron surface or any other surface, most of the metal surfaces are combined with that of your corresponding oxide formation from the reaction with the air or sometime sulphide formation or the carbonate formation through the reaction with the carbon dioxide of the air.

So, all these material basically that means, when we clean it or react with those surfaces that means if it is a oxides or a hydroxide surface or they carbonate surface of the metal, we treated with the hydrochloric acid such that your hydrochloric acid will take care of the corresponding anionic part as your metal anionic form, that means the corresponding anions can be taken away.

And if possible if we are able to reduce that particular free metal ion on the surface, you can get the metal as the metal ion as the zero form, again it can come and attach or stick to the metal surface, otherwise it can be cleaned or it can be least from the metal surface as the typical metal ions salt of the corresponding chloride ion which is available from hydrochloric acid.

So, if a metal surface is covered with hydroxide or the oxide or the chloride surface itself, if we can treated with hydrochloric acid, and if the solubility of the already present carbonate surface or the chloride attached to it, it is also not very much. But the fresh amount of addition of hydrochloric acid we will clean it as the corresponding metal salt from the surface such that we get a very shiny surface or a very clean surface because we require most of the cases when we directly use in the industry that we see also afterwards when we talk about the corresponding industry which is producing the high grade of metal center, high grade of silicon center which are having a huge demand in the industry. So, metal cleaning process is can be utilized through the use of the product of our industry is the hydrochloric acid.

Then sometime not typical cleaning, but we considered as industrial is known as the pickling. So, like the pickling of the metal surfaces or the metals all the metals material also is also done by the hydrochloric acid, and sometimes the manufacture of metal chlorides from the free metals or the metal oxides, hydroxides, carbonates or different types of ores and minerals.

So, how we go for getting that particular metal as the metal salt? If the industry is only devoted to something where we do not produce the metal itself, but we are directly producing or converting the ore or mineral to your metal ion salt that mean iron we take hematite or magnetite for the production of ferric chloride say or the iron sulphate or ferric nitrate. So, making these for the different types of chloride that means, the ferrous chloride or ferric chloride, we directly treats those metal or the metal oxides with that of your hydrochloric acid.

Then in the typical classroom or the research level laboratories, they are using huge amount of hydrochloric acid for simple neutralization reactions. So, that neutralization reactions in any chemistry of inorganic organic or some biological world also the biochemistry the bioinorganic classes or the biophysical classes, the first thing what we

do that if you have a solution and that solution also very important industrially also when there will be some adjustment in the pH.

Suppose our raw material is a simple sea water that will see in our next class possibly. That if we try to get the bromine out of the sea water, because the bromine concentration as bromide in seawater is very less, but for getting that particular bromide as the free bromine we should have some reaction that we will see, but before that we have to go for the typical neutralization reaction.

So, the neutralization reaction for the different types of organic and inorganic reactions or sometimes for the bulk material things are very simple that how we neutralize it. When we neutralize we are talking in terms of the corresponding neutralization in terms of the basicity of the carbonate, the bicarbonate or the corresponding hydroxides or the oxides.

When we go for the neutralization, we are taking care of the pH of the medium, but if we just try to ignore the corresponding supply of the anions out of the acid, what we are using, because when you use hydrochloric acid and a huge excess of hydrochloric acid if we add to adjust the pH, to control the pH by the time we are contaminating the reaction medium with huge amount of chloride ions which is coming out directly from the HCl.

Similarly, if the medium is not good enough to sustain with that of your excess chloride, we should try with that of our other acids, other inorganic acids, other mineral acids like that of your sulphuric acid or nitric acid if chlorides are not good enough for the particular type of reaction what we are looking for. But in most of the cases hydraulic acid is the preferred one or HCl gas passing HCl gas in the gaseous form also is the most useful one for neutralization reactions.

Then proton catalyzed or acid catalyzed reactions in the biochemistry or in other areas are well known. We know that a typical reaction we always follow is the hydrolysis reaction. So, HCl is again a very good material for the hydrolysis reactions of proteins and carbohydrates it is giving you for the corresponding idea that it can go for the lysis reaction than means the breaking of some bonds like ester hydrolysis or any other thing, where water is basically attacking that particular bond that means, the ester bond is getting hydrolyzed to give you the acid and alcohol back, but that particular acid either it can be acid catalyzed or base catalyzed.

So, most of the cases if it is acid catalyze so these hydrochloric acid or HCl is very good to go for this type of hydrolysis reaction for the proteins, the peptides, the polypeptides and the different types of carbohydrates also. Then one more important thing is that what we are also study now is the making new molecules out of this HCl. One such new molecule is like that of your chlorine oxide if we move from chlorine to chlorine oxide for water treatment acid treatment of oil wells and all these things.

So, when we go for acid chlorine oxide we can go use it for corresponding water treatment as well as acid treatment of oil wells also, that means, the adjustment of the corresponding ph of the acid wells also. And if we are not able to put directly the HCl we will use the chlorine oxide; that means, Cl 2 O.

When we produce this HCl and most of the time what we produced as a byproduct and since the byproduct amount if it exceeds to a value that means, huge amount of HCl we are producing through that particular industrial activity. And what we find is that that HCl produced through this particular process by that thing is a byproduct. And when it exceeds the demand; that means, whatever amount of HCl we require and whatever amount of HCl we produce which exceeds the demand, then we have the excess amount how we can consume that particular excess amount of HCl. There is no worry to make we can only convert back again because we know the procedure how you can convert the chloride that is NaCl to chlorine also.

Similarly, you have again a good quality of chloride supplies that means, the chloride ion supply as HCl and that chloride ion supply will be utilized for converting back again to chlorine. So, we can have the remaining amount what is not required from HCl utilization we will convert directly it to again the chlorine gas, we can preserve it in the cylinders or any other store house.

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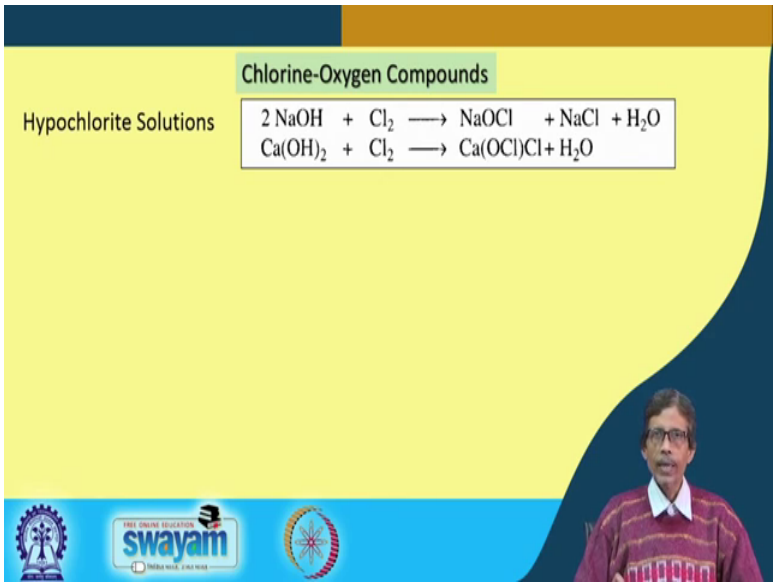

Then as I told you that we can see how we make this particular chlorine attached with oxygen, that means, we will definitely have some chlorine oxygen bond. Earlier we are making Cl 2, then we are making HCl bond. And HCl bond is also very much useful for breaking and creating of the new bond, now we are moving to some species where you can have the chlorine oxygen bond; that means, how it is possible to convert the corresponding one as the oxidation of the chlorine if we consider that attachment of the oxygen atom to the chlorine center.

So, one such example as we all know that is the typical making of the hydro chloride, sodium hypochlorite we can make it. How we make it, sodium hypochlorite is nothing but the bleach we use, the common day laundry bleach, the washroom or the bathroom bleach so common days we are bleaching agent. So, that bleaching agent is nothing but NaOCl as we know the bleaching powder the name is also because now a but nowadays we do not use that much bleaching powder. Because in the acidic medium or the aqueous medium it is produced in free chlorine and free chlorine is always harmful for our health or body and is also harmful for the environment.

So, a dilute solution of hypochlorite instead of using calcium OCl, COCl, we can use sodium hypochlorite NaOCl only. So, there is no chance of getting free chlorine out of this. So, we have this how we make it. So, the second reaction is the production of your bleaching powder with just simply compare side by side how we can get this of making

hypochlorite from calcium hydroxide. So, we get this calcium hydroxide react with the chlorine at room temperature, mostly is the room temperature reaction giving your bleaching powder per water.

Similarly, if we pass chlorine gas that is why when we produce chlorine and you can get that chlorine and the supply of that particular chlorine gas, you can pass it to a saturated solution of sodium hydroxide is sufficiently concentrated sodium hydroxide solution giving you both NaOCl NaCl plus water. And the same reaction when you have the bivalent cation; such as that of your calcium which is the bivalent cation. And this particular reaction is nothing but base assisted this proportionation reaction between the formation of chloride as well as the hypochlorite ions.

So, making of this chloride and hypochlorite ions through this proportionation reaction in basic medium, we are producing two anions. So, when we have mono cation that is sodium ion, the sodium ion will take care of both these two anions producing NaCl as well as NaOCl. But when you have the bivalent cation that means calcium hydroxide is there, so already you have calcium bound to hydroxide groups. And if we can able to convert one of them as OCl and another as the Cl which is being applied to it. So, we get the calcium having that both these two are chloride, and hypo chloride ions attached to this particular calcium center.

So, the problem is that when we added in the acidic medium, again the hypochlorite and chloride will combine in presence of three or excess protons are the H plus producing water as well as the chlorine and the calcium hydroxide from there . So, we can avoid that particular thing if we can separate these two thing because if we can produce sodium hypochlorite and sodium chloride together what we will find that these two together can have the fractional crystallization itself, that means, if they can have the different solubility and that solubility difference will tell us where we can go for crystallization of sodium chloride, and where we can go for the crystallization of sodium hypochlorite.

So, separate crystallization what we call the fractional crystallization process only giving you the production of sodium chloride; half of the molecules will be the sodium chloride production as well as the sodium hypochlorite solution. This way will be making the huge amount of sodium hypochlorite solution because the sodium hydroxide is also a very cheap material. And if we are able to get chlorine out of the sea water and all other

sources, we can get sodium hypochlorite also. So, in our next class, we will be considering how these hypochlorites or these bleaching agents are also useful and other chlorine oxygen compounds.

Thank you very much.