Main Group Chemistry
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Lecture – 60
Overall Summary

Hello everyone. This is my last lecture in this is series of 60 lectures on main group chemistry. Today let me concerned at whatever I discussed in the last 59 lectures. So, before I start that one, I am showing you some of these reference books I have used here advanced inorganic chemistry 6th edition.

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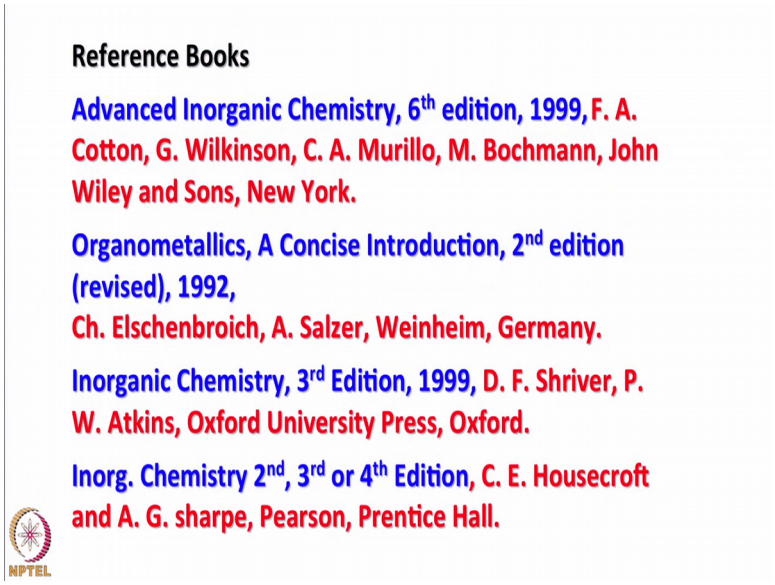

And also organometallic chemistry; a concise introduction by Elschenbroich and also inorganic chemistry a third edition by D F Shriver and Atkins and inorganic chemistry; one can use second third or 4th edition by C E Housecroft and A G Sharpe. Besides this, I have also taken some information from Wikipedia and other internet sources and also some journals of course; wherever I have taken I have mentioned the articles details.

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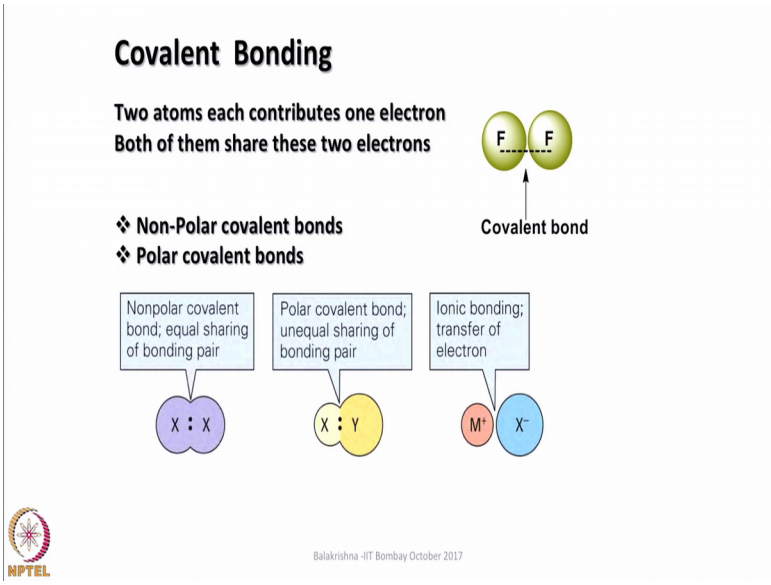

So, we can look into it. So, let me begin with about covalent bonding and of course, the bonding concept is very very important whether we considered main group chemistry or transfer metallic chemistry and we should be able to distinguish between the type of bonds we come across in a molecule.

For example, if we see ff covalent bond is there and covalent bond can be non-polar covalent bond or polar covalent bond, non polar covalent bonds are very stabled and if you want to do any reaction with such molecules; we have to first polarize and make it polar covalent bond then only reaction happens. For example, when we come across non polar when you come across polar can be clearly a known by looking into the 2 atoms which are contributing electrons. For example, non polar covalent bond equal sharing of bonding pair will be there; that means, if the electro negativity difference is marginal then you have a non polar covalent bond if the electronegative difference is considerable.

Then we have polar covalent bond and of course, if the electronegative difference is too large then that leads to the formation of ionic bond.

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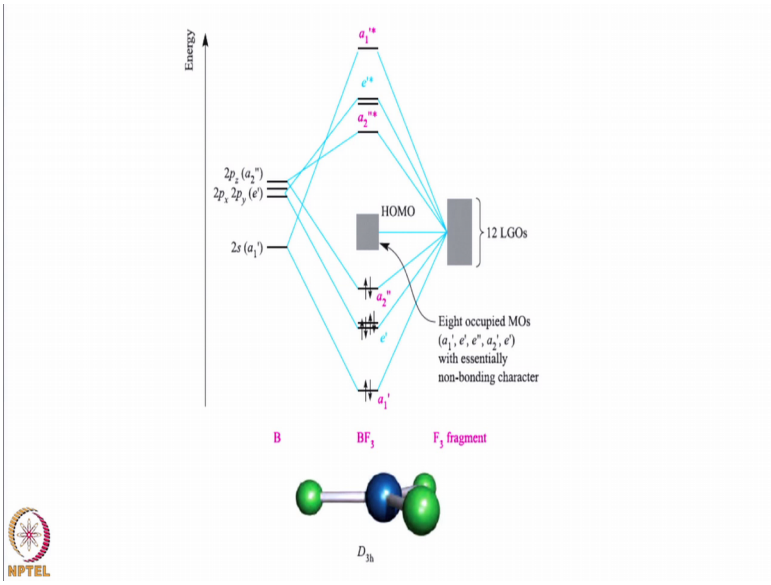

And let us look into the m o diagram; I have given here for BF 3. Sometime, we think that writing mo diagram; diagram for polite molecules is little complicated it is not really. So, here at least one of the central atom will be there and several other atoms will be binding to the central atom this several atom peripheral atoms. So, essentially a we considered the orbitals from those as ligand group orbitals. For example, look into BF 3 here in case of BF 3 we have a total of 24 electrons, 7 each from fluorine atoms 7 into 3 21 and 3 electrons from boron s 2 p 1. So, now, we have to accommodate these 24 electrons and first let us look into a Lewis dot structure.

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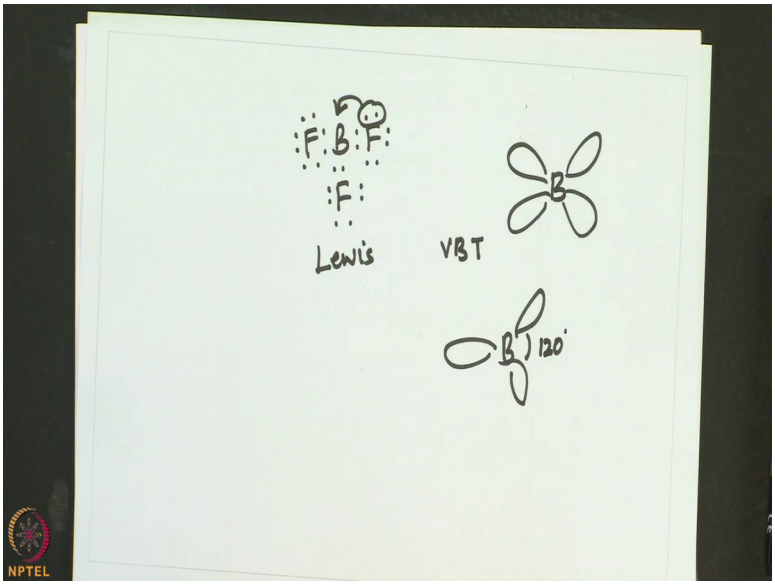

Of course when we write Lewis dot structure for BF 3, we simply write like this and here update is not satisfied for boron because it has only 6 electrons and of course, this is less Lewis acidic compared to B cl 3 because of 2 p 2 p interaction. So, these 2 electrons might come here. So, that it can give little bit of completion of the update 2 electrons and in case of this is Lewis dot structure in case of valence bond theory what we do is boron undergoes sp 2 hybridization hence. So, this is tetrahedral is not possible. So, basically what happens it undergoes sp 2 hybridization angle is 120.

So, what we say here of course, here you do not talk about update satisfaction here it is electron deficient. So, then how to write mo diagram mo diagram is shown here you can see; that means, essentially 12 ligand group or 8; that means, here 3 fluorine atoms are giving 21 electrons and then 3 electrons are coming. So, totally we have 24 electrons out of 24 electrons, if you see here 6 electrons are essentially used for making 3 boron to fluorine bonds and now this one whatever I have shown here this one is responsible for making p pi p pi interaction to remove little bit of electron deficiency; that means, these 2 electrons are coming from fluorine atom and now with this one we have left with about out of 24; 8 or the 16 electrons are these 16 electrons essentially remain here as 8 pairs nonbonding.

So; that means, still molecular orbital theory gives a complete picture and also it shows the possible p pi p pi interaction between fluorine and boron to remove its electron deficiency and hence this 4 face can be considered as satisfying the update of boron so; that means, basically lot of information comes and better information comes from molecular orbital theory.

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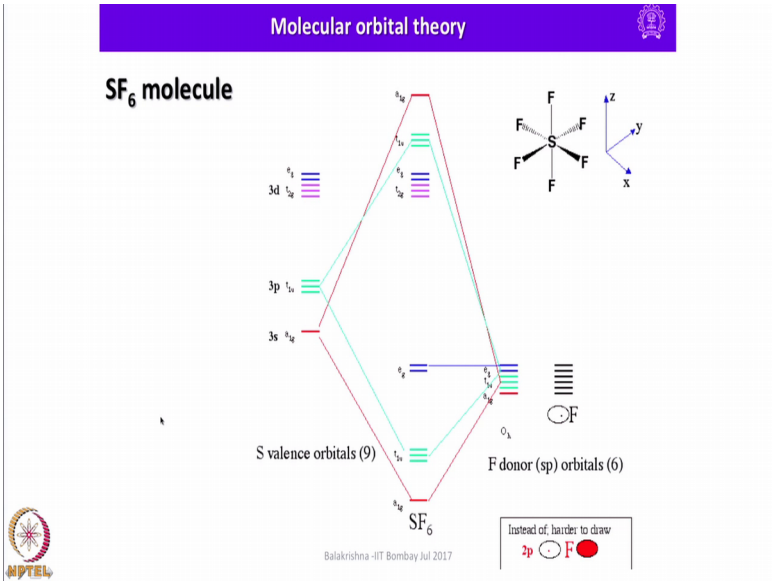

Let us look into one more example here SF 6 molecule and SF 6 molecules if you go to the valence bond theory we assume that Sulphur undergoes sp 3 d 2 hybridization and it generates 6 hybrid orbital having one electron each and that combines with 6 fluorine atoms to form an octahedral molecule having 12 electron surrounding it, but if you look into the mo diagram here; here in the 3 d energy is very high compared to 3 p and 3 s as a result it is less likely that they will participate in bonding.

This is actually mo diagram for SF molecule here and they are not participating as a result what happens only 8 electrons are coming here and remaining 4 electrons are essentially remain and non bonding and they stay on almost fluorine orbitals or an fluorine atoms so; that means, this shows that SF 6 is a hypervalent molecule and same one or as you can also; we extended to disodium hexafloro silicate na 2 sif 6 so; that means, there will be some difference in the understanding of the bonding between valence bond theory and a molecular orbital theory, but; however, molecular orbital theory gives a better picture of the structural aspects that are there in each and every molecule and of course, this is a polyatomic molecule as I said poly atom molecule can be understood in this faction.

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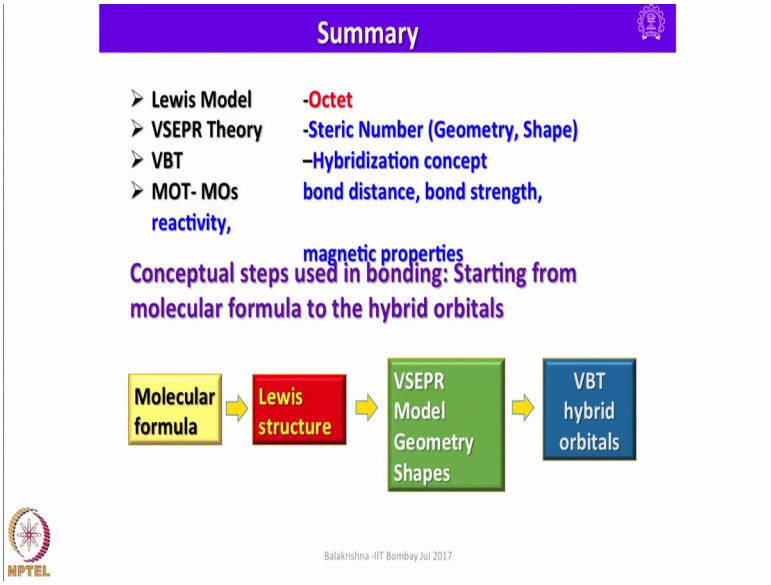

A summary about structure and bonding is if we began with Lewis model where we showed update and also its limitation and also VSEPR theory, it gives Steric numbers and also it produce geometry as well as shape then valence bond theory with hybridization concept again a; it gives about geometry as well as shape and molecular orbital theory gives bond distance bond strength and also it give some idea about the reactivity of those molecules and also magnetic properties. So, concept conceptual steps used in bonding starting from molecular formula to the hybrid orbitals, you can get information from one or other of this bonding concepts; however, for the understanding of the complete physical and chemical properties one has to go for molecular orbital theory.

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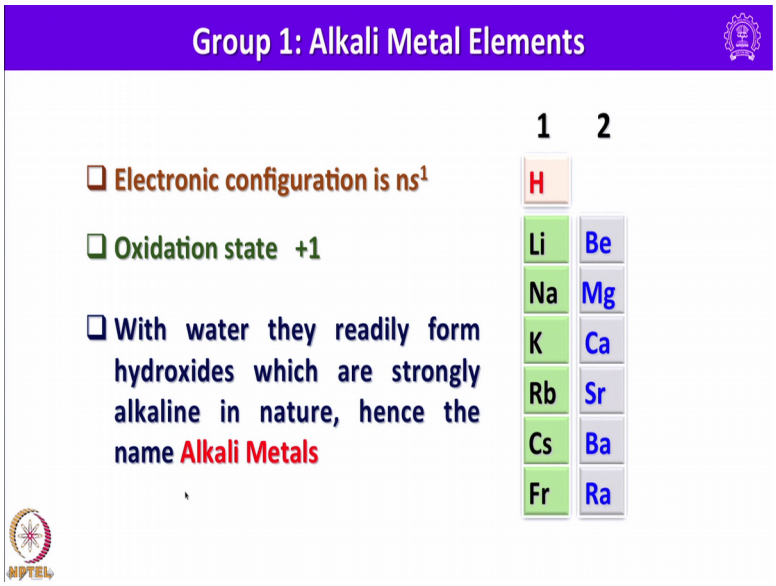

And let us begin with group one of course, group one we have only one electronic it is a valence shell and the oxidation state is plus 1; they do not show any other ox state other than plus one with water they readily form hydroxides which are strongly alkaline in nature.

Hence name alkali metals so; that means, all their oxides are basic in nature they react with water to give the corresponding hydroxides.

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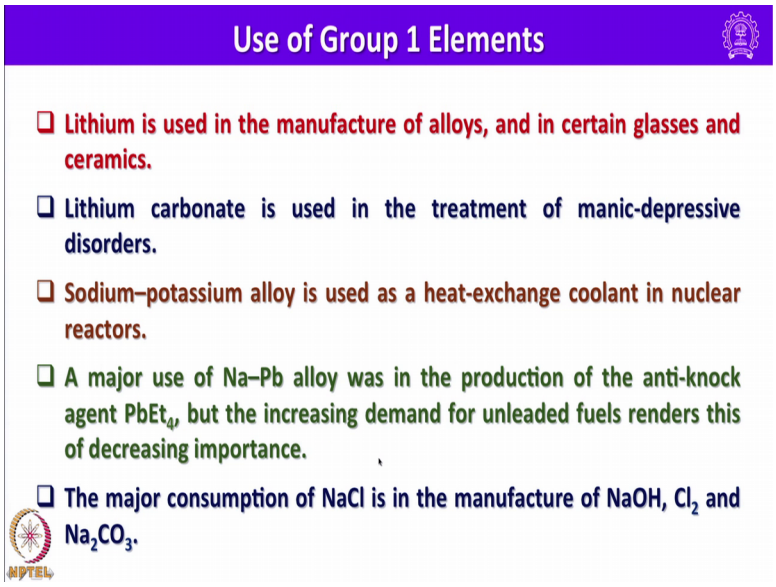

And of course, I also discussed uses of group one elements lithium is used in the manufacture of alloys and in certain glasses and ceramics lithium carbonate is used in the treatment of manic depressive disorders and sodium potassium alloy is used as a heat exchange coolant in nuclear reactors a major use of sodium. Let the alloy was in the production of antiknock agent such as tetraethyl lead it is no longer used, but increasing demand for unleaded fuels renders it is; this of decreasing importance the major consumption of sodium chloride is in the manufacture of sodium hydroxide chlorine and sodium carbonate.

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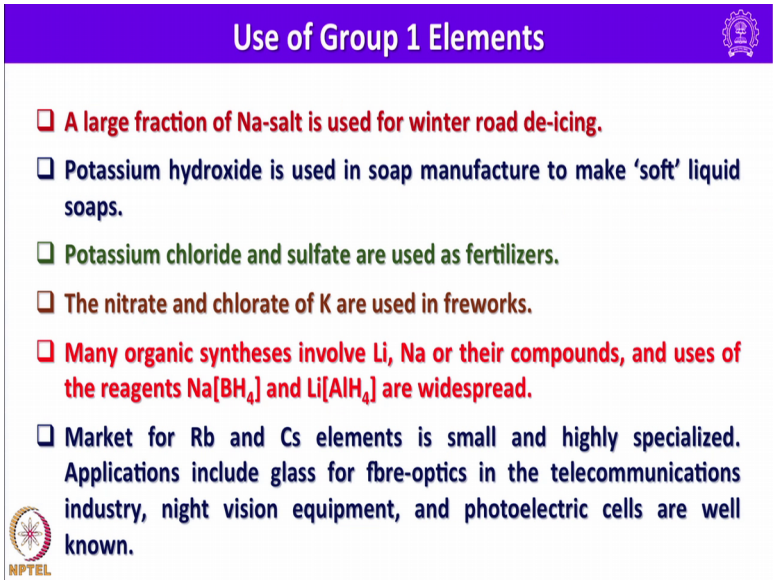

And a large fraction of sodium salt is used for winter road de icing c in cold countries potassium hydroxide is used in soap manufacturing to make soft liquid soaps potassium chloride and sulphate are used as fertilizers nitrate and chlorate of potassium are used in fireworks many organic synthesis involve lithium sodium or magnesium and their organometallic derivatives.

Market for rubidium cesium elements is small and highly specialized applications include glass for fiber optics in the telecommunication industry night vision equipments and also photoelectric cells these elements are used.

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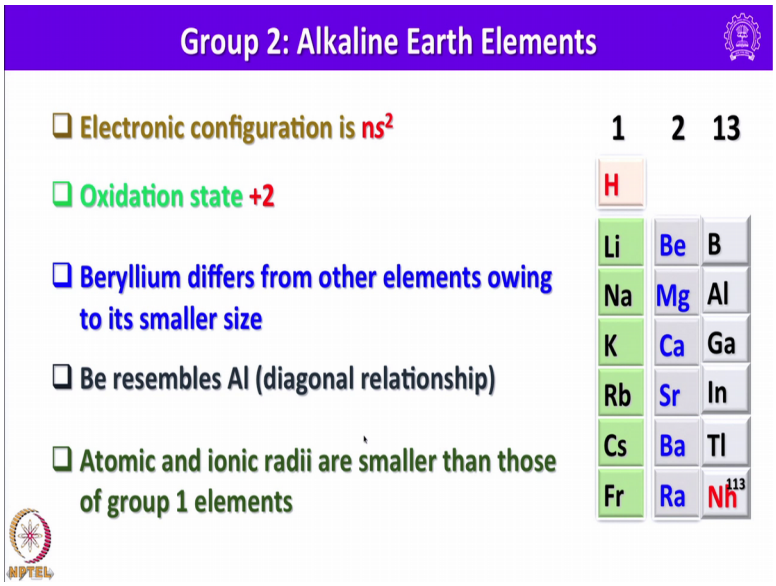

And in case of alkaline earth metals having ns 2 electronic configuration earth state is plus 2 and beryllium differs from other elements owing to its smaller size that is too in case of almost all elements in the first row the chemistry of first 2 elements are slightly different because of the smaller size and high charge size ratio and beryllium resembles aluminium, we introduce the diagonal relationship and atomic and ionic radius smaller than those of group one elements and of course, alkali metals have the largest size in the row and the least francium with the largest atom known and a helium with the smallest in the periodic table out of hundred and eighteen elements.

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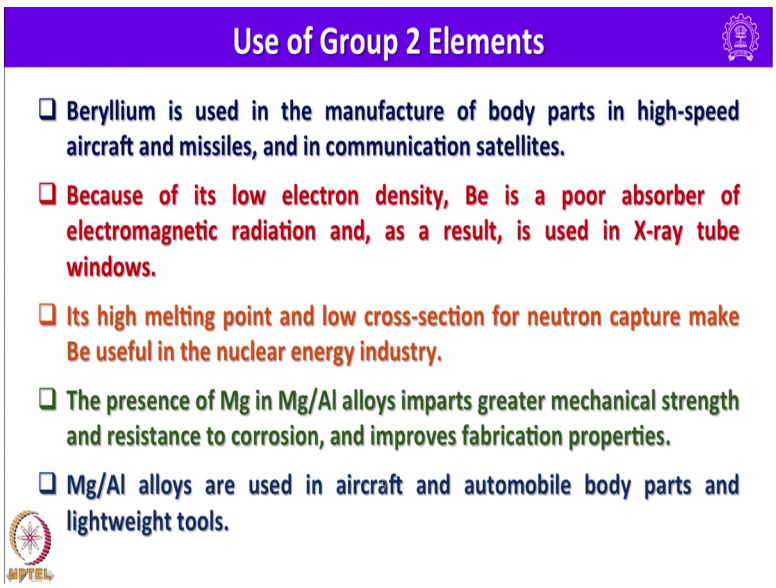

Beryllium is used in the manufacture of body parts in high speed aircraft and missiles and also in communication satellites because of its low density beryllium is a poor absorber of electromagnetic radiation and as a result it is used in x ray tube windows its high melting and low cross section for neutron captures make beryllium useful in nuclear energy industry the presence of magnesium in magnesium alloy imparts greater mechanical strength and resistance of corrosion and improves fabrication properties as a result and also because of the lighter nature magnesium, aluminium alloys are used in aircraft and automobile body parts and lightweight tools.

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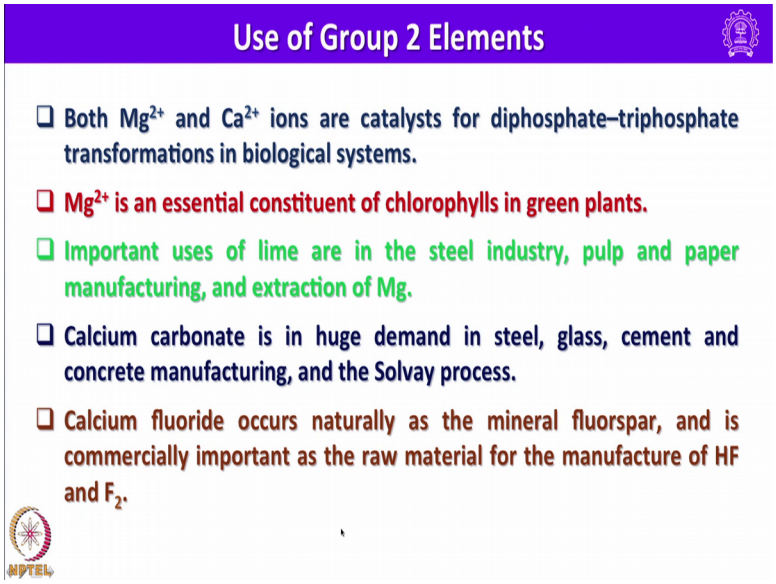

And both magnesium and calcium ions are caterers for diphosphate; triphosphate transformation in biological system that is very very important magnesium 2 plus is an essential constituent of chlorophyll in green plants important use of lime or in the steel industry pulp and paper manufacturing and also in extraction of magnesium.

So, calcium carbonate is in huge demand in steel glass cement and concrete manufacturing and also in Solvay process and calcium fluoride occurs naturally as the mineral fluorspar and is commercially important as the raw material for the manufacture of HF and fluorine gas.

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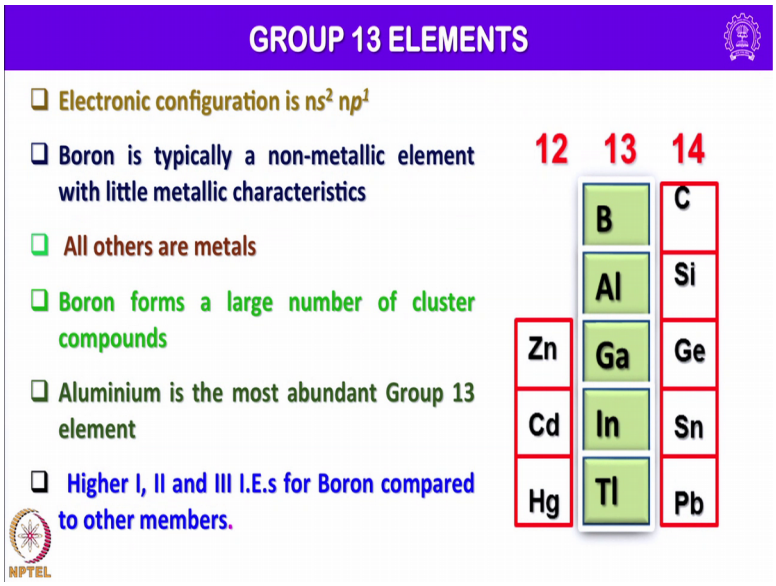

Let us come to the group 13 having ns 2 np 1 electronic configuration the group ox state is plus 3; however, when you go down the group that tendency to have a lower coordination comes into the picture because of inert pair effect and inert pair effect begins. In fact, in with group 13 also indium partly shows inert pair effect inner pair effect is more concerned in case of thallium as well as group 13 elements are concerned and then its spread across tin and lead and also it moves on to group fifteen elements as an antimony and bismuth and then tellurium.

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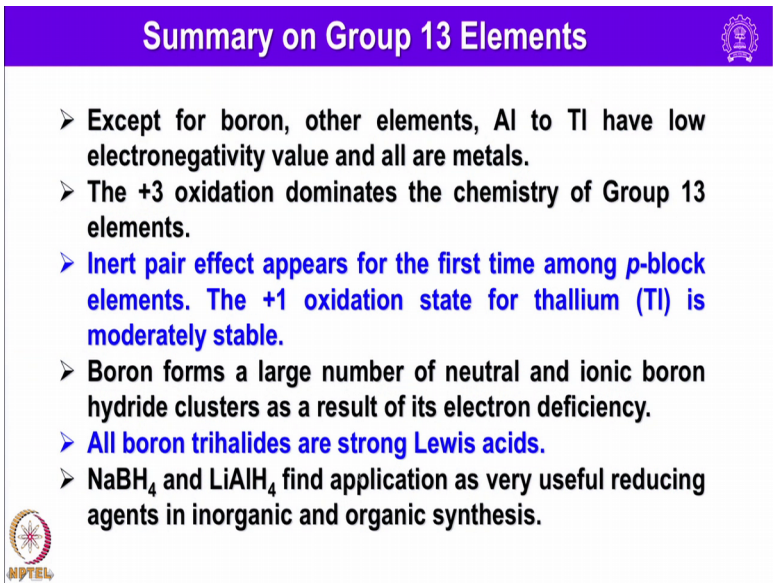

And except for boron other elements have low electronegativity value and all are metals as I said plus 3 ox state dominates the chemistry of group 13 elements and plus 1 ox state is reassembly stable for thallium and in 5 plus 3 is oxidizing in nature and sodium borohydride and lithium aluminium hydride find application has very useful reducing agents in inorganic and organic synthesis and all boron try halides are strong Lewis acids.

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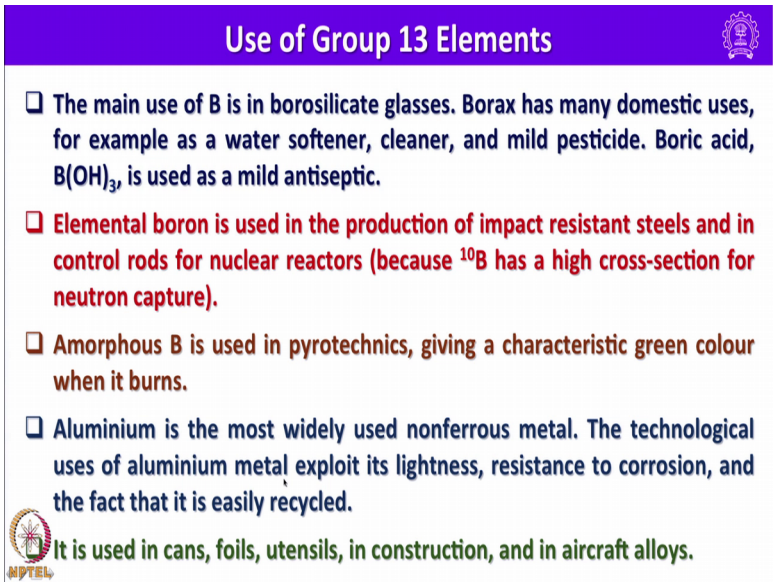

The main use of boron is in borosilicate glass borax has many domestic uses for example, as a water softener cleaner and mild pesticide boric acid is used as a mild antiseptic as well elemental boron is used in the production of impact resistant steel and in control rods for nuclear reactors amorphous boron is used in pyrotechnics giving a characteristic green color when it burns aluminium is the most widely used non ferrous metal the technological uses of aluminium metal exploit its lightness resistance to corrosion and in fact, it is easily recyclable it is also used in cans foils utensils in construction and also in aircraft alloys.

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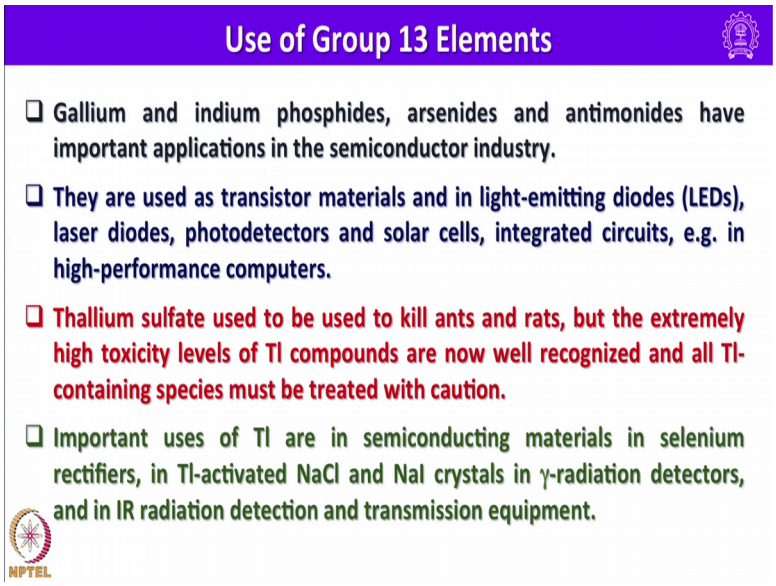

And gallium and indium phosphides, arsenides and antimonides have important applications semiconductor industry. In fact, there is semiconductor properties are much superior to the silicon semiconductors, they are used as transistor materials and in high light emitting diodes laser diodes photo detectors and solar cells integrated circuits example in high performance computers thallium sulphate was used to kill ants and rats, but the extremely high toxicity level of thallium compounds are now will recognized and as a result they are not used as poisons.

Important uses of thallium or in semiconducting materials in selenium rectifiers in thallium activated sodium chloride and sodium iodide crystals in gamma radiation detectors and also in IR radiation detection and transmission equipments.

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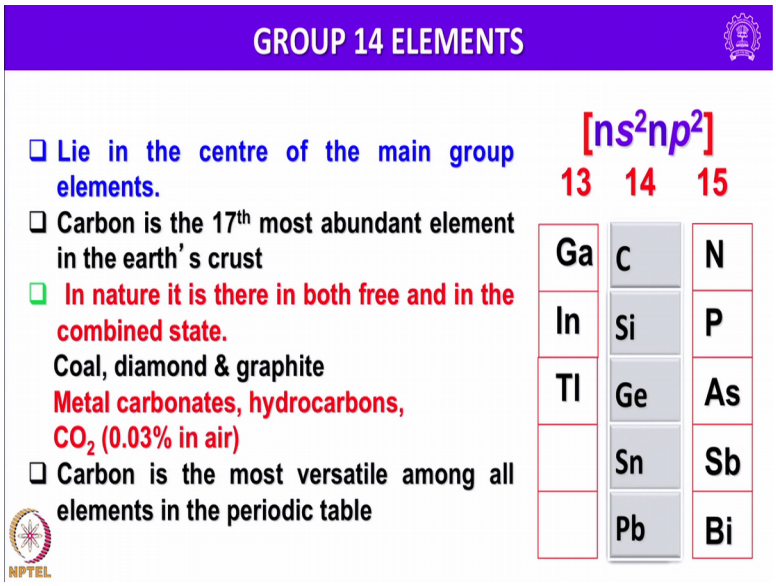

So, group 14 with ns 2 np 2 electronic configuration are almost with the middle of the main group elements of course, carbon is well known for its organic chemistry and also catenation and silicon finds uses in semiconductors.

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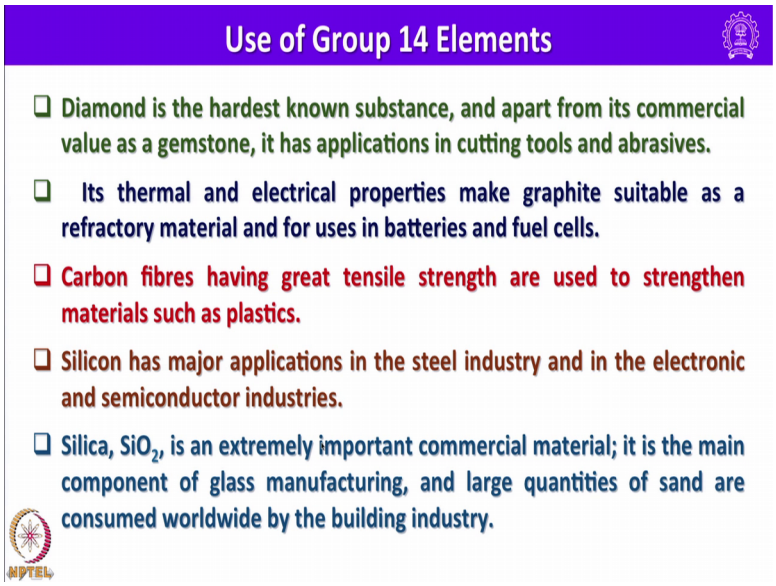

And diamond is the hardest known substance and apart from its commercial value as a gemstone it has application in cutting tools and abrasives its thermal and electrical properties make graphite suitable as a refractory material and for uses in batteries and fuel cells carbon fibers having great tensile strength are used to strengthen materials such

as plastics silicon has major application in the steel industry and in electronic and semiconductor industries.

Silica is an extremely important commercial material is it the main component of glass manufacturing and large quantities of sand are consumed worldwide by the building industry of course, we have in India. Now, the scarcity of silica that is the sand for construction.

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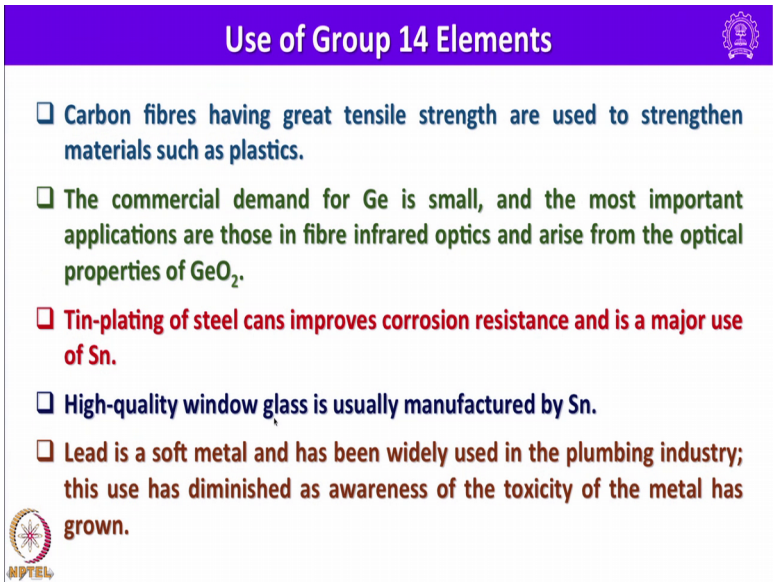

Carbon fibres having great tensile strength are used to strengthen materials such as plastics the commercial demand for germanium is small and the most important applications are those in fibre infrared optics and arise from the optical properties of germanium oxide tin plating of steel cans improves corrosion resistance and is a major use of tin high quality. Window glass is usually manufactured by tin lead is a soft metal and has been widely used in the plumbing industry this use has diminished as awareness of the toxicity of the metal has grown nowadays that is the reason you are now those who come for look into this problems has called plumbers as earlier plum-bum the was used in this water pipes and other things and also in plumbing.

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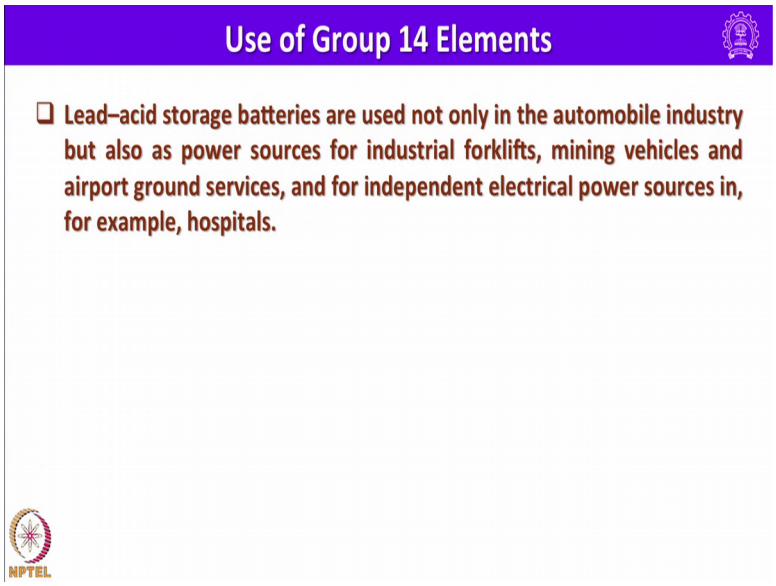

So, lead acid storage batteries are not only in the automobile industry, but also as power sources for industrial forklifts mining vehicles and airport ground services and for independent electrical power sources.

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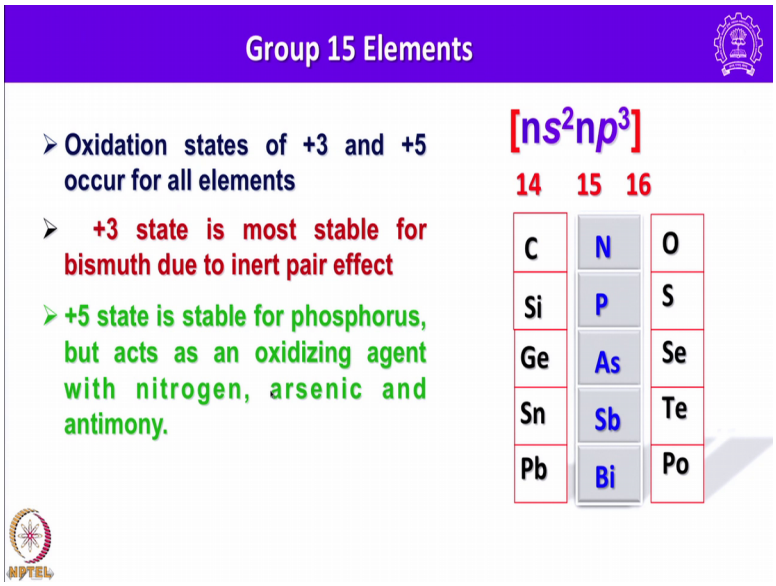

And also in hospital group fifteen elements show plus 3 as well as plus 5 as a group oxidation states plus 3 state is most stable for bismuth due to inert pair effect and tendency to have plus 5 state decreases down the group again because of inert pair effect the urgent shows minus 3; 2 plus 5 oxidation state and phosphorus shows both plus 3 and

plus 5 oxidation states and plus 3 compounds are widely used as ligands in coordination chemistry and organometallic chemistry and the. So, some of this fast fins find application in homogenous catalysis and of course, group fifteen elements are also called as pnictogens and they have nonmetal in nitrogen to main group metal bismuth.

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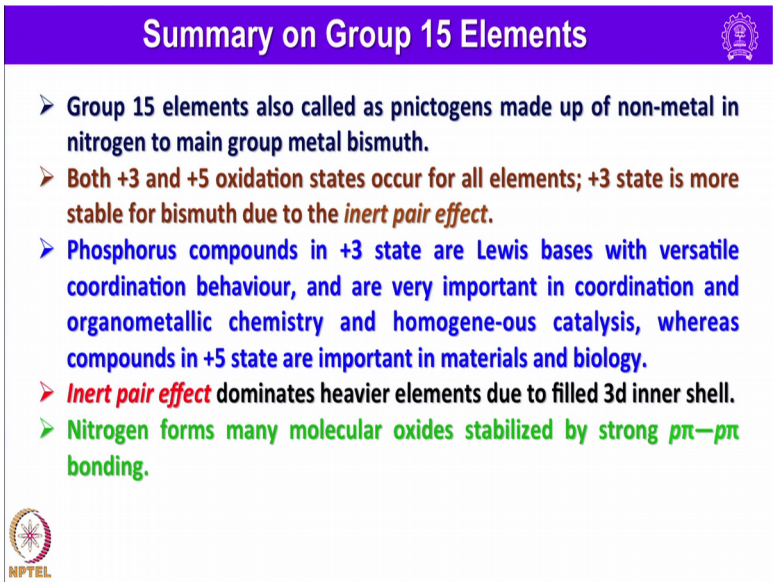

Nitrogen is essential for the industrial production of ammonia and nitric acid the major non chemical use of nitrogen gas is an inert atmosphere in metal processing petroleum refining and food processing.

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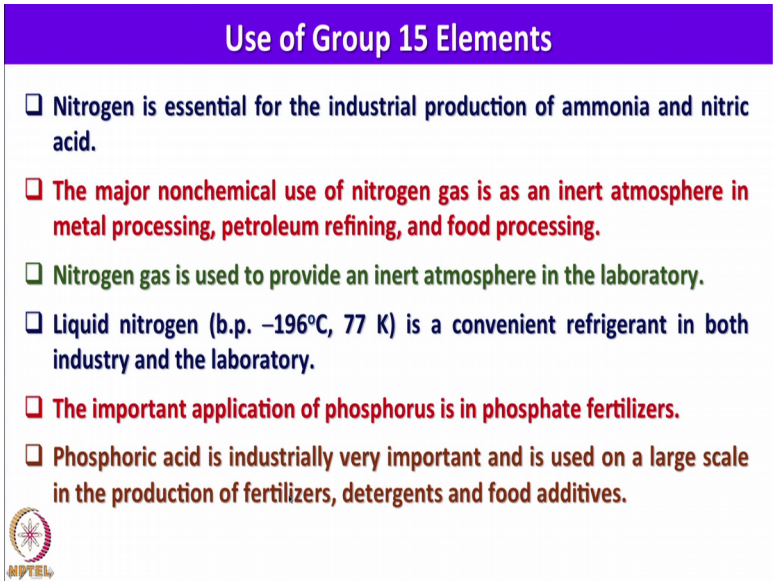

Nitrogen gas is used to provide an inert atmosphere in the laboratory liquid nitrogen is a convenient refrigerant in both industry and in the laboratory with boiling point minus 196 degree centigrade the important application of phosphorus is in phosphate fertilizers phosphoric acid is industrially very important and is used on a large scale in the production of fertilizers detergents and food additives arsenic salts and arsines are extremely toxic.

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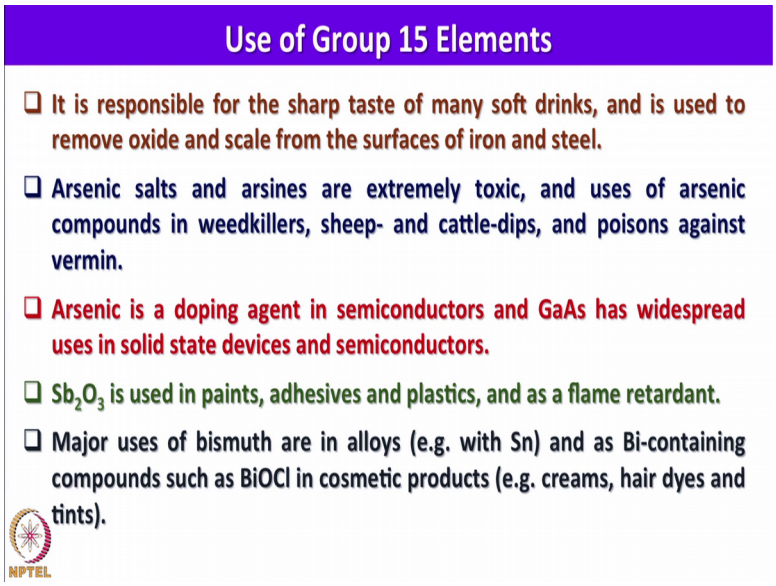

And uses of arsenic compounds in weedkillers, sheep and cattle dips and poisons against vermin arsenic is a doping agent in semiconductors and gallium arsenide has widespread uses in solid state devices and its semiconductors. And Sb2O3 antimony trioxide is used in paints adhesives and plastics and as a flame retardant as well measure uses of bismuth are in alloys with tin and as a bismuth containing compounds such as BiOCl; BiOCl in cosmetic products the creams hair dyes and tints.

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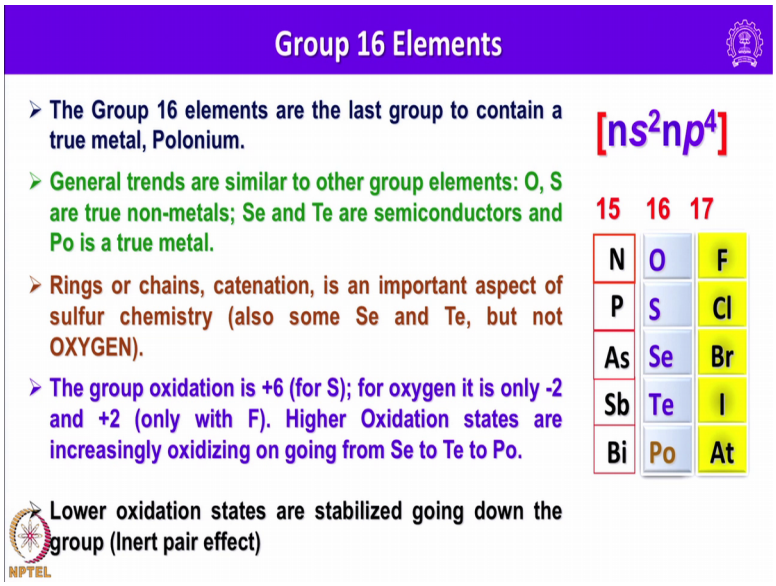

Group 16 has ns 2 np 4 electronic configuration of course, the group oxidation state is minus 2 and also it can also go to up to plus 6. In case of Sulphur, oxygen, it only minus 2 and is shows plus 2 ox state only when its combined with fluorine and oxygen is the second most electronegative element in the periodic table next to fluorine and lower oxidation states are stabilized in case of heaver group 16 elements because of inert pair effect the important use of oxygen is as a fuel for oxy acetylene and hydrogen flames as a supporter of respiration and a special conditions and in steel manufacturing Sulphur mail in the form of sulphuric acid.

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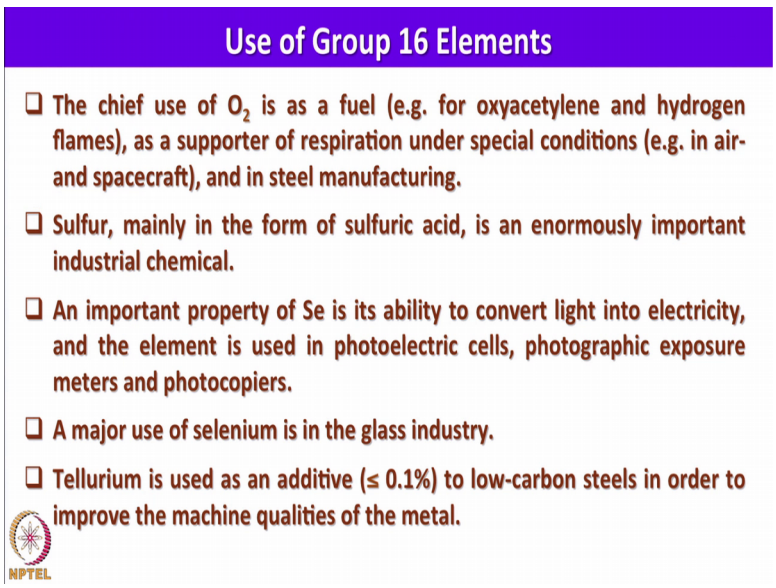

An important property of selenium is its ability to convert light into electricity and the element is used in photoelectric cells photographic exposure meters and photocopiers a major use of selenium also is in the glass industry tellurium is used as an additive a less than point one percent to lo carbon steels in order to improve the machine qualities of the metal.

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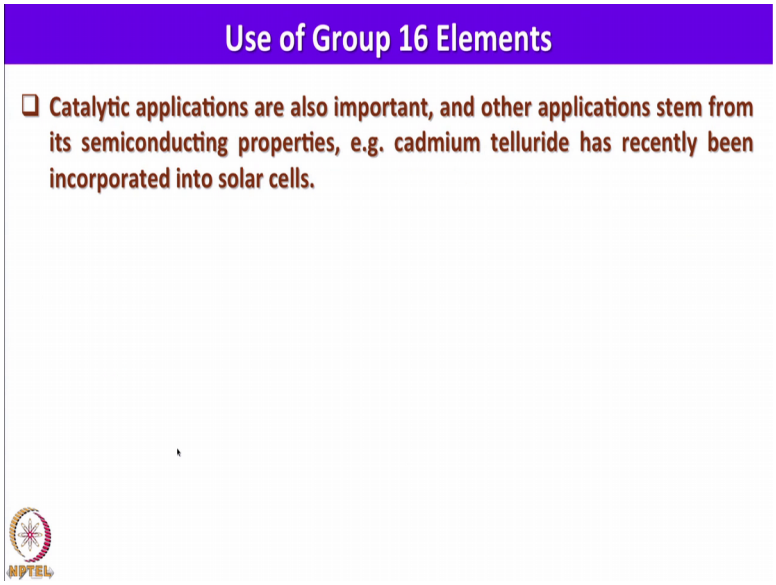

The catalytic applications are also important and other application stem from its semiconducting properties.

Its example cadmium telluride has recently been incorporated into solar cells of course.

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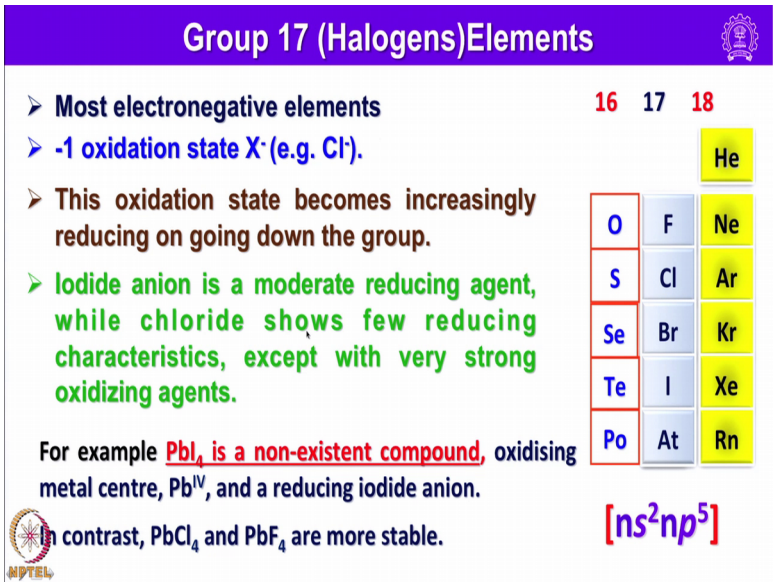

When you go to group seventeen group ox state is minus 1 there the most electronegative elements in the periodic table polonium is the metal. It has the metallic property and it is the last one in the periodic table to show metallic properties and pb I4 is a nonexistent compound because it is a combination of highly reducing iodine and highly oxidizing lead in its plus 4 state.

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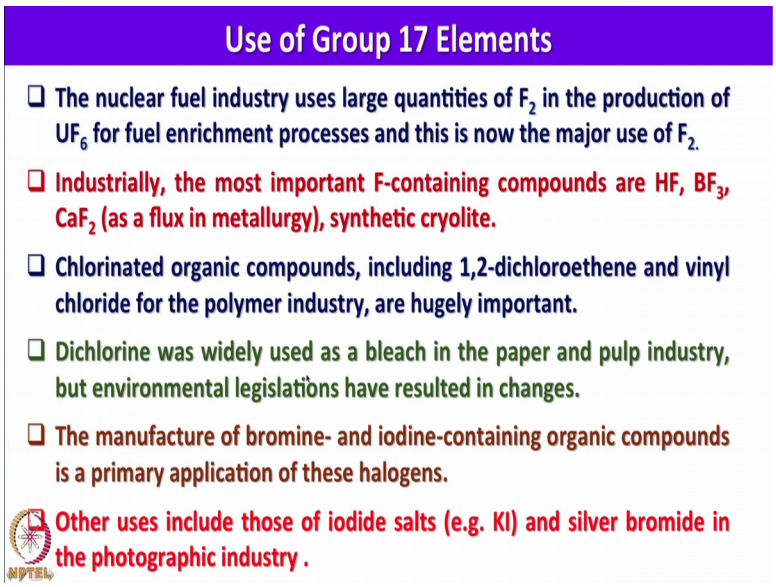

Yeah the important uses of group seventeen elements includes like the nuclear fuel industry that uses fluorine in the production of UF 6 uranium hexafluoride for fuel

enrichment process and this is now the major use of fluorine industrially the most important flooring containing compounds are HF, BF 3, CaF 2 and synthetic cryolite chlorinated organic compounds including one 2 dichloroethane and vinyl chloride for the polymer industry are hugely important dichlorine was widely used as a bleach in the paper and pulp industry. But environmental legislations have resulted it is in the changes the manufacture of bromine and iodine containing organic compounds is a primary application of this halogens and of course, other uses include those of iodide salts and silver bromide in the photographic industry because of digital photography now this silver bromide is no longer used.

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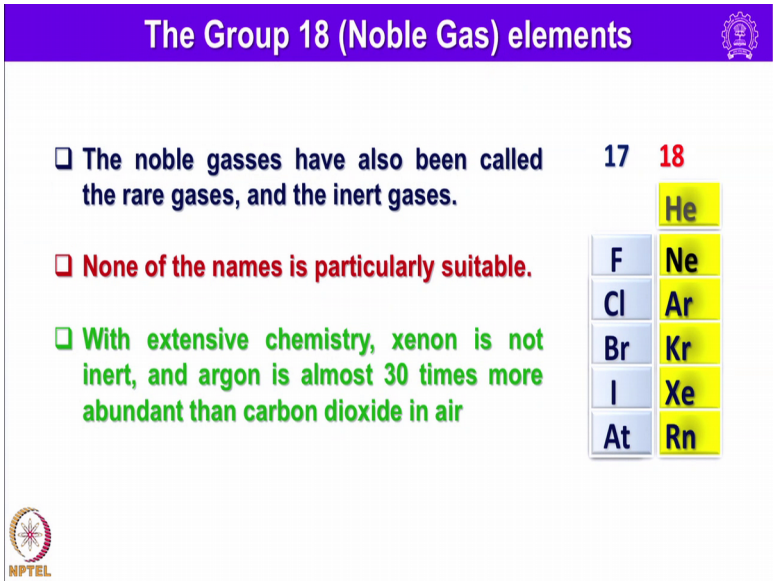

Noble gases also show some reactivity and we saw lot of compounds of xenon and few compounds of krypton with extensive chemistry xenon is not really in inert and as I said organ is almost thirty times more abundant than carbon dioxide in atmosphere.

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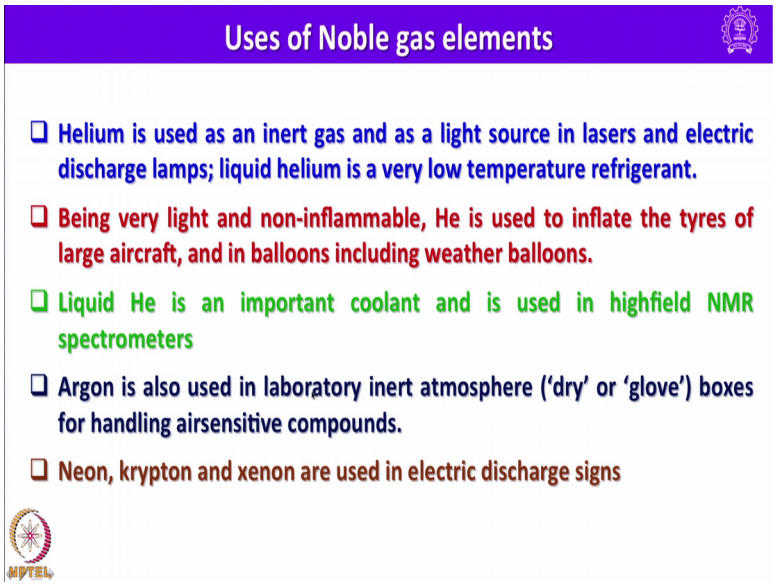

Helium is used as an inert gas and as a light source in lasers and electric discharge lamps liquid helium is a very low temperature refrigerant being very light and non inflammable helium is used to inflate the types of large aircraft and in balloons including weather balloons liquid helium is an important coolant and is used in highfield nmr spectrometers argon is also used in laboratory inert atmosphere a boxes for handling airsensitive compounds and neon krypton and xenon are used in electric discharge science. So, with this let me come to the conclusion this learning process is very very important and one should have always hard for learning anything and especially chemistry because we are all having one of the sophisticated laboratories in us.

Just look into our own body all kind of mechanical, biological, everything happens in our body; I do not think man can ever make something like this. So, being the proud owners of such a sophisticated chemical laboratory within us is it not embarrassing if you do not know some chemistry from that point of view, I think we should know some basic chemistry and it will enrich our knowledge and without chemistry I can tell you there is no life if you take anything a chemistry component is there. So, as a result learning chemistry helps us in understanding many things in day today life. So, be greedy for learning be content with earning and of course, when you listen to a class room lecture in the limited period of time a teacher may not be able to give all the details pertinent your particular topic and he can only give the abstract or little more than what you can think of.

But it is not enough on the other hand you have to go to write text books and you had to enhance your knowledge and also make a note of it and then the learning process will attend some completeness and then at the end you will be having some satisfaction with this I conclude my lecture and I made an effort to teach main group chemistry in a very simple manner for which what I did was I simplified all wast and chemistry of main group elements into just 4 categories; that means, interaction of main group elements with hydrogen to form hydrates and interaction of all main group elements with oxygen and the chalcogenides to form oxides and sulphide, selenide, tellurides and then interaction of all main group elements with halogens to form the halides and the fourth category of compound includes organometallic compound; that means, interacts the main group elements with organic mods is carbon fragments and carbides and also borides and nitrates.

So, when we look into each of this component and when we study group wise and in 2 groups we come across that one for example, if we take sodium oxide or calcium oxide we study sodium oxide in group one and also when you go to group fifteen group 16 in the way when you go for calcium oxide we understand from the point of calcium from the group 2 that is alkaline earth metals and when you go to oxygen we understand the chemistry from the oxygen point of view. So, when we learn like this; this is just 4 class of compounds just about understanding anything and everything will be very easy and also all fundamental aspects you go for electronegativity atomic size ionic size electron attachment enthalpy electronegativity..

All those things are very nicely imbibed periodic trends and periodic properties in the chemistry of main group elements once we thoroughly understand the chemistry of main group elements understanding just about anything no matter where this chemistry component comes recognizing it and its role can be understood very easily from this point of you I believe learning main group chemistry is very very important and its a stepping stone to understand all other aspects of chemistry no matter where it appears with this again I repeat the quote that I may be greedy for learning and be content with earning and if you have any query you can always write to me I have given my email address.

Thank you very much.