

my name is maruvanji shivramya balakrishna that is ms balakrishna i am a professor of chemistry at the indian institute of technology bombay mumbai i have been there since 1996 teaching in organic chemistry all aspects of inorganic chemistry and also doing research in the broad field of inorganic chemistry my research interests include the chemistry of main group elements and transfer elements and also we design new phosphines and phosphorus based compounds to explore their coordination chemistry organometallic chemistry and also their possible utility in organic transformations as homogeneous catalysts we also study anti-cancer properties of copper one complexes of phosphines and containing some pyridine ligands when it comes to the course that i am going to offer it has about 12 to 13 lectures and i have classified the main group chemistry into four categories one is chemistry of manure elements forming hydrides that is main group element hydrides and main group element oxides and main group element halides i have also included the interaction of main group elements with carbon and organic moieties to form organometallic compounds are organo element compounds in this course ah after giving some introduction to the periodic table classification of elements periodic trends and periodic properties i have also spoken about the bonding concept that is used in main group chemistry however i could not do justification for molecular orbital theory that i will be doing at later stage and

so because of time constraints i could not include several other aspects concerned with main group elements in this course for example solving problems and application of some of these elements in various uses and also the chemistry we come across in day to day life

so all these things i have planned in my next course that is going to be coming in january 2018 there is a full fledged course that has all aspects of main group chemistry that includes spectroscopic aspects all bonding aspects and also several problems and how compounds can be characterized using various nmr techniques and other things and also in between i am trying to include some fascinating stories of elements and their discovery besides talking about some chemistry that we see in day to day life for example you take onion no matter what the price of onion is whether it's 20 rupees or 200 rupees whether who is cutting it where it is cut for what purpose it is cut and how it is cut everyone who cuts it cries or it brings tears in the eyes of the person who cuts it on a lighter note it's an exemplary and universal secular vegetable jokes apart then what is the chemistry behind onion making people cry in fact when you are cutting onion a chemical called propane thiol s oxide sulfur oxide is released that interacts with another enzyme present in onion to generate sulphur trioxide sulphur tri acid is a gas when it starts moving it interacts with moisture present in the eyes to form sulfuric acid that starts irritating our eyes and more and more tear comes to dilute it and wash it away and for example $s + 3h_2o \rightarrow h_2so_4$ like that many interesting things are there that i would like to share with you in my next series of lectures on chemistry of main group elements and this before my lecture my email address will be displayed and you are most welcome to give suggestions and also if you have any queries you can always write to me and all those things i will try to include in my next lecture series with your kind permission i would like to begin my lecture series i hope you will enjoy and if you will learn some chemistry through my lectures welcome to my first lecture on the chemistry of main group elements ah in this lecture i will be discussing about the important aspects of the arrangement of elements and periodic properties that means the classification of elements and periodic properties before i get into this one i would like to speak about some of the important people or individuals who have contributed significantly to arrange some of the known elements then in some

order to understand their physical and chemical properties

so in this regard several people have worked however when the modern periodic table came into picture the major architect was russian chemist dimitri mandalu several other contributed significantly to mendeleev's periodic table

so let us discuss some of those things and today in the classification of elements and periodic properties aspect what we are going to understand is the position of elements that means in what way elements are kept in a particular group and how they are related to the remaining elements in the group and also in that particular row that means how group wise classification was made what are the parameters that were looked into before classifying these elements group wise and period wise and then we shall look into periodic trends that means the relative atomic size electronegativity electron affinity ionization enthalpy all those aspects how they are related to atoms in each period or in a group and then naming the elements of course ah now 118 elements are known all of them have been named however in future if some elements are discovered say for example having atomic number 120 133 r140 how to name them for this iupac has given some norms and how to follow that one we shall look into it later and also the classification of elements into s p d and f block elements that means basically how they were classified that means if they have electrons in the the valence electrons if they have valence electrons in s orbital they are essentially called as s block elements and if they have valence electrons in the p block p orbitals they are called p block elements similarly if they have valence electrons in d and f they are called as d and f block elements and then we shall look into the significant periodic trends in physical and chemical properties and then we can also look into the comparison of reactivity of elements that means what are the important compounds we come across with respect to main group elements and how we can compare with other compounds of same type with other groups that means essentially we can also draw a relationship between ionization enthalpy and metallic properties

so let us look into the basis for classification of elements its a known fact that elements are the basic units of all types of matter including both living as well as non living things and you will be surprised to know if you look into the number of elements known in the past until 1800 only 31 elements were known in the next 65 years the number rose to 63 and by 1984 that is after almost 120 years 107 elements were known and another five elements were added in 1997 and in 2004 113 and 114 elements were discovered and in 2016 we have now 118 elements and out of these 118 elements 90 elements plus neptunium plutonium actinium pro octanium which exist in uranium war such as pitch blend are stable elements and the rest are radioactive ah let us look into the contribution of some people before dmitry mandela proposed his periodic table in 1800 german chemist john dob reiner then available elements he made into several groups of three elements and he called them as triads for example i have listed some of them you can look into it lithium sodium and potassium were kept in one group calcium strontium and barium were kept in another group and similarly chlorine bromine iodine were kept in another group and he made an important observation the observation was the atomic weight of the middle one was almost the average of the first and the third element that you can see clearly sodium has atomic weight of 23 and if you take the sum of the atomic weights of lithium and sodium that comes around 46

so that means sodium has 23 half of that one and similarly calcium atomic weight is faulty and barium atomic weight is 137 together it comes around 177 and the strontium atomic weight is almost half of that one it is 88 same trend was seen in case of ah halogen series given here bromine atomic weight is eighty it is half of the or average of the atomic weights of chlorine as well as iodine

he made this observation however it done this observation did not give much information about the arrangement or their periodic trends or properties and later french geologist alexandre brcon john in 1862 arranged then known elements in the order of increasing atomic weight and he made a cylindrical table of elements to display the properties of those elements known and during the same time another english chemist called john newland in 1865 he arranged the elements in increasing order of their atomic weight and he noted very important point that every eighth element having the properties similar to the first element and this was called the law of octaves in fact those who are familiar with music notes they can recall every eighth note being similar to the first octave of music and this whatever the octave method john proposed was good up to calcium and not fully accepted however for his painstaking work royal society london awarded davy medal in eighteen eighty seven and later in eighteen hundred and sixties two chemists one from russia dimitri mendeleev and lothar mayor from germany worked independently to arrange these elements in a proper order in 1869 both succeeded in arranging the elements in the increasing order of their atomic weights and showed the similarities appearing in physical and chemical properties at regular intervals lothar mayor plotted physical properties such as atomic weight melting point boiling point against atomic weight and showed periodically repeating pattern in contrast to octave format suggested by john mayor identified the change in the length of the repeating pattern and in in 1868 he was ready with almost the modern periodic table however he did not publish his results meantime russian chemist dmitry mandelstam published his periodic table in 1869 with an important statement i quote the properties of the elements are a periodic function of their atomic weight i repeat again the properties of the elements are a periodic function of their atomic weight manually arranged then known elements in horizontal row and vertical columns in a table with increasing order of their atomic weight in such a way that elements with similar properties occupy the same vertical group the interesting intelligent aspect is he gave importance to similarities in the empirical formula and properties and atomic weight was not strictly followed wherever there was controversy for example despite lower atomic weight of iodine if you have periodic table very handy you can have a look at it in fact the atomic weight of iodine is much lower compared to tellurium however while sorting out these dimitri place tellurium in group 16 along with oxygen sulphur and selenium and placed iodine in group 17 along with fluorine chlorine bromine and iodine and what he did was actually correct

so also he predicted the properties of some unknown elements and he left gap in the table at appropriate places for example he left gap below aluminum and also below silicon and called the elements to be discovered as eka aluminum and eka silicon

so he predicted the existence of gallium and germanium they were discovered later and described their general properties before they were being discovered and you can see some of his early work and his hand written things are given in this slide of course this was taken directly from wikipedia the web details are given below this one if you are interested you can read that article and get more information mendeleev's 1871 proposed periodic table was published in 1905 you can see here his first periodic table was in this form and when mandaluy proposed his periodic table the structure of atom and electrons were unknown in fact electrons were discovered by j j thompson only in 1897 and modern atomic theory was proposed by niels bohr in 1913 work of english physicist henry mosley on x-ray spectra of elements and atomic theory showed that the atomic number Z is a more fundamental property of an element not actually its atomic weight so mandalas periodic law thus modified as i quote the physical and chemical

properties of the elements are periodic functions of their atomic numbers i repeat again the physical and chemical properties of the elements are periodic functions of their atomic numbers not atomic weight as it was suggested earlier atomic number of an element is equal to its nuclear charge that is in a neutral atom if you consider the number of electrons are essentially equal to the number of protons in the nucleus thus by simply knowing the electronic configuration it is possible to recognize the periodic variations and trends across a period or in a group since periodic law is governed by the electronic configuration the variation in electronic configuration determine the physical and chemical properties of elements and their compounds you can see the the skeleton of periodic table is shown here ah it is classified into four ah groups or four blocks one is s block having ah alkali metals and alkaline earth metals that is ten elec ten elements plus hydrogen sitting in the alkali metal group that is the s1 block and s2 block then we have six p block elements starting from s two p one electronic configuration to s two p six of noble gases or inert gases then we have 3 d 10 blocks you can see here s 1 block s 2 block and we have p block having 30 elements plus 1 helium 31 and then we have three ah d block elements that is three d four d and five d each one having anywhere between one to ten electrons in their d orbital then we have thirty f block elements belongs to four f and five f group

so this is how all the elements are classified in the periodic table and and earlier notation if you see the numbers given very different for example alkali metal and alkaline earth metal that is s block elements were called one a and two a and then d block elements were called as three b four b five b six b seven b in the same sequence and the three next groups were called as eight and without giving any ah alphabet and then ah one b and two b were given to copper and zinc group and then boron group was considered as three a and carbon was four a ox nitrogen group was five a and oxygen group was six a and uh halogen group was seven a and inert gas for eight a now the entire period table is classified into 18 groups starting from 1 to 18 and most of the textbooks are also following the numbering as 1 to 18 not following a or b type it is convenient to follow the group on group 2 like that that means group 1 group 2 and group 13 14 15 16 and 17 are main group elements whereas 3 to 12 are essentially called d block elements and this is the the present periodic table you can see all 118 elements have been named properly and let us say we have some unknown elements as i mentioned earlier and if unknown elements are there for example having atomic number greater than one one eight how to name the name them for that one iupsc has made some formula and we can see that one here for example we have to use the corresponding name and observation for numerals 0 should be called nil and n and if it is 1 that is u n un and then observation will be u it continues like that and similarly if you have digit nine that name should be n e n n and abbreviation is n for example if you want to name an element having atomic number one one nine

so in one one nine we have one one and nine we can use n m that means the first letter should be capital and then the second one you consider only first letter and the the last number also consider one letter

so that it becomes u u e that is union similarly if you want to name an element with atomic number one three four there should be un and the abbreviation is utq symbol is utq and similarly for 146 one can name it as unquad hexium and uqh similarly for fifty eight one can conveniently name it unpaint octium that is u p o

so this is how unknown elements can be named and for example if element one one is discovered what is its electronic configuration

so as i had mentioned earlier

so we have 118 elements known and have been numbered for example for Z equals 118 the name is oganesson and one can also write its electronic configuration as starting from radon the previous inert gas element in fact oganesson belongs to inert gas element group and the electronic configuration of oganesson is $[\text{Rn}] 5f^{14} 6d^{10} 7s^2 7p^6$ now we can consider this as an inert gas and simply we can write the atomic number of Z one one nine electronic configuration of Z one one nine as $[\text{Fr}] s^1$ in the bracket and simply s^1 that means if an element with atomic number one one nine is discovered that belongs to alkali metal group having one electron in s orbital in its valence shell and it will be placed below the alkali metal francium

so electronic configuration is nothing but the distribution of electrons into the orbitals all alkali metals have one electron in their valence shell that is having s^1 electronic configuration whereas alkali earth metals have s^2 electronic configuration that is two electrons in their valence shell similarly p block elements have $s^2 p^1$ to $s^2 p^6$ electronic configuration that is where that means they have three to eight electrons in their valence shell similarly d block elements have $s^2 d^1$ to $s^2 d^{10}$ electronic configuration having anywhere three to twelve electrons in their valence shell that means essentially three block starts with atomic number 21 with scandium ends with zinc that is atomic number 30 and the 4d series starts with atomic number 39 for yttrium to 48 for cadmium and 5d group starts with hafnium with atomic number 72 and ends with mercury that is 80 and 4f starts with lanthanum 57 to lutetium and similarly five block starts with actinium to 89 and ends with francium

so both are inner transition elements that is f and f block are called inner transition elements and I have listed here the electronic configuration for first group elements it is very easy to write you can follow this sequence and of course this obeys the Aufbau principle and all whatever that is proposed to arrange the electrons in the increasing order of their energy

so you can see sodium atomic number 11 potassium atomic number 19 rubidium 37 cesium 55 and francium 87 either you can expand it and write fully or you can take the previous inert gas configuration and just add the valence cell electron present in it

so for example when you are writing francium its atomic number is 87 the previous inert gas is read on with 86

so you can write $[\text{Rn}] s^1$ same sequence is followed in case of all elements whether they are from group one group two or group three

so now let us look into some of the periodic properties and when we talk about periodic properties we should know what are the terms we should be familiar with one is ionization energy or ionization enthalpy and electronegativity or electron attachment enthalpy and electron affinity or electron attachment affinity and electronegativity

so these three terms we should make familiar

so that understanding of the properties should be very easy

so what we are going to learn is the concept of ionization energy or ionization enthalpy and electronegativity in surveying the periodic table in the properties of the oxides chlorides and hydrides of main group elements and of course after making some of these compounds in order to understand their geometry and shape we have to have a proper bonding concept

so here the most appropriate bonding concept is VSEPR theory that is valence electron pair repulsion theory and the use of VSEPR in predicting the basic molecular shapes and basic molecular orbital theory for describing the bonding in atomic molecule can be conveniently used here and ionization energy and electron affinity should be referred as ionization enthalpies and electron

attachment enthalpies though energies are commonly used in latest textbooks instead of using ionization energy they refer it as ionization enthalpy and similarly for electron affinity they call it electron attachment enthalpy

so one can follow conveniently the new convention and now let us look into ah the formation of compounds

so what would happen when an element forms a chemical bond its basically the atoms can lose an electron or atoms can gain an electron or atoms can share a pair of electrons

so that leads to the formation of chemical bond if the chemical bonds are formed what are the types of chemical bonds we have and how to decide the nature of the chemical bond for example we have ionic bond is there and also covalent bond is there again covalent bonds can be classified into two categories polar covalent bond and non polar covalent bond apart from that one we have some weak forces that holds some of these atoms or molecules together they are called van der waals interactions london forces and also hydrogen bonding let us learn all these things in a systematic way for example when a atom in its plus say n plus oxygen state loses one electron to go to next higher auction state that is called the ionization

so that means

so this information as i said ah while making a chemical bond either electrons are lost either electrons are gained or electrons are shared with other atoms and how to analyze this one means it essentially about knowing the nature of a particular atom whether it is ready to give an electron ready to gain an electron or ready to share an electron that information comes from some of this periodic properties called ionization enthalpy electro negativity and electron attachment on enthalpy i have given some first ionization energy in this table here you can see that for lithium it is plus 526 kilojoules per mole and for sodium it is 502 kilojoules per mole whereas for potassium it is plus 425 kilo joules per mole and for rubidium it is plus 409 and for cesium it is plus 382 kilojoules per mole you can see some trends that is followed here if you see carefully these values are decreasing as you progress from lithium to cesium ah why this ionization energy is decreasing

so essentially when you go down a group the electrons are added to the next higher shell as a result what happens atomic size increases as the atomic size increases the valence electrons move further away from the nucleus as a result they are held less firmly compared to the same in lighter elements as a result what happens when they move little further from the nucleus removal of those electrons would be easy as a result what happens in a group the heavier elements show the lower value for ionization energy and similarly ionization energy is given for potassium and aluminium here for comparison because in case of potassium we have first ionization energy that is very low and in case of aluminum we have s two p one electronic configuration you can anticipate the removal of three electrons to generate ah aluminum three plus the first ionization energy for potassium and aluminium are four twenty five and five eighty four and second ancient energy is three zero five eight and one eight two three and third ionization energy is four four one eight and two seven five one that means you can always look into those values and you can analyze and judge why the values are

so in case of potassium it is very easy to remove the electron from its valence shell whereas in case of aluminum there is an increment in the nuclear charge as a result it is a bit difficult to remove the p electron and of course once of removing the p electron then you have to remove the two electrons that becomes much easier and in case of potassium now we have to remove the electron from the inner core that is very difficult as a result second and third ionization energy

increases remarkably

so potassium for the same reason does not show other higher oxidates and its oxy state is plus one whereas aluminium can show conveniently plus three states after analyzing the first ionization energies of group one elements and also looking into first second and third ionization energies of potassium as well as aluminium ah we have got some information about these things that means this whatever the this information we get about ionization energy it will tell us about the nature of the bond types whether they are going to be ionic or covalent and by knowing this chemical and physical properties of substance can be predicted very easily ionization energy essentially refers to the loss of an electron from the gaseous atom or ion this ionization energy decreases down a group increases along a period compare the charge to size ratio that would tell you more information about that one i would show you the relative sizes of all elements in the periodic table in a couple of minutes let us look into the plot of the first ionis energy for the element starting from lithium to calcium you can see clearly here ah the values corresponding to lithium here of course here helium and hydrogen is given and the lithium shows ah relatively low ionization energy compared to these two that is anticipated here because of the increase in the size of lithium whereas when we move from lithium to beryllium ah the first ionization g increases here and again in case of boron it drops and then it continues until we have nitrogen and again drops in case of oxygen here the question is nitrogen and oxygen if you compare the electro negativity oxygen is being more electronegative than nitrogen however the first ionization energy of oxygen is much lower than nitrogen it is simply because nitrogen has $s^2 p^3$ electronic configuration $s^2 p^3$ because of half filled p orbital it is relatively stable compared to $s^2 p^4$ electronic configuration shown by oxygen that means oxygen has a tendency to lose one of the electron readily to attain $s^2 p^3$ electronic configuration as a result the first ionization energy of oxygen is little lower compared to first ionization energy of nitrogen and same analogy can be explained again ah in case of phosphorus and sulfur whereas in case of magnesium it goes up from sodium because here effective nuclear charge increases that means by looking into the position of the ah elements and their electronic configuration and effective nuclear charge we should be able to analyze the first ionization energy of the elements and you can see here electronic configuration i have shown here ah beryllium we have to remove essentially the two electrons and in case of boron you have to remove three electrons the first electron comes from two p in case of nitrogen we have $n^2 s^2 p^3$ electronic configuration in case of oxygen we have $s^2 ah p^4$ electronic configuration

so this electronic configuration added with electro negativity and also the effective nuclear charge and the atomic size can tell you the trends and also how to guess the relative ah values without much difficult that means the kinks in the ionis energy we see in this plot for boron and o can be explained simply by looking into the electronic configuration now look into the second ionization energy and first ionization comparison is made in this plot and again the trends whatever we follow in the first ionization energy is very similar to what we observe in the second ionis energy of some of these elements shown here and i have also given the electronegativity value on polling scale here for some important elements as i said fluorine is the most electronegative element having the value force point zero whereas the next most electronegative element is oxygen having three point five and the electronegative values of chlorine as well as nitrogen are more or less comparable little fractional difference is there however both of them show very close to 3.0 value whereas carbon has 2.

5 as well as sulfur has 2.

5 hydrogen electronically is 2.

1 and boron has 2.

0 value and alkali metals are least electronegative and sodium shows about 0.

9 and similarly if you look into first electron affinities fluorine shows minus 322 kilo joules per mole and whereas chlorine shows little higher than fluorine that is minus three forty nine kilojoules per mole whereas bromine value is minus three twenty five and for iodine it is minus two ninety five kilo joules per mole that means here the first electron affinity for fluorine it is little less compared to chlorine simply because the size of fluorine is much smaller when you are putting additional electron to make it f^{-} as you are essentially putting eight electrons very close to the smaller atom and because of inter electron repulsion its electron affinity value is much lower compared to chlorine whereas in chlorine because of little larger size it can accommodate comfortably the electron taken to make it as chloride anion that means the electro negativity refers to the tendency of an atom in a molecule to attract electron to itself the most widely used scale is divided by Pauling as I had mentioned this is based on bond energies the most electronegative elements are in the top right of the periodic table with fluorine being the most electronegative with a maximum value of four zero on Pauling cell and least electronegative atoms are in the s block that is s one and s two block that is alkali metals and alkaline earth metals

so electronegativity is a very useful general parameter for predicting the general chemical behavior of an element and gives good indication of bond types two elements with large electro negativity difference will tend to form ionic compounds for example halides when they interact with group one or group two elements for example if you consider sodium chloride its the bond is ionic in nature small electronic differences are enough when one of the element is highly electro positive metal two elements with very similar or intermediate electronegativity values will tend to form covalent bonds for example if you consider C-H bond in methane it is covalent in nature the electronic difference between the carbon and hydrogen is minimum that means carbon has 2.

5 whereas hydrogen has 2.

1 as a result you can anticipate it to be a covalent bond and I have shown here the relative atomic sizes of all elements in the periodic table you can see carefully and each group atomic size increases and in each row atomic size decreases the reason is very simple and if you consider elements given in a group steadily the size is increasing as more and more electrons are added to the next higher shell and as a result what happens atomic size increases and the group 1 last element is largest atomic size it has whereas helium has the smallest atomic size and if you see for example period 2 where we have lithium beryllium boron carbon nitrogen oxygen fluorine and neon here basically the added electrons are going to the same shell as a result effective nuclear charge is increasing as a result the added electrons are coming very close to the nucleus and you can see the shrinkage of atomic size

so these trends are followed in all the groups for example you take any group the heavier elements are larger in size and atomic size steadily increases down the group and the atomic size steadily decreases across a period

so that means now let us look into the main group elements and their compounds and based on the bonding types ok we can classify the compounds of main group elements into ionic covalent or polymeric to molecular the general features of the chemistry of the main group elements and their selected compounds can be understood simply by analyzing and rationalizing the variation in

electronegativity of the elements as a very very useful qualitative tool the most important components of main group elements are hydrides oxides and halides and of course we can also consider another group of compounds such as organometallic compounds are interaction of main group elements with carbon or organic moieties that means overall although it appear like enormous all available compounds of main group elements can be simply brought simply classified into four categories the interaction of all elements with hydrogen to form hydrides all elements of main group elements to interact with oxygen to form oxides and also that can be extended to other oxygen group elements such as sulfur selenium and tellurium and also the interaction of all main group elements with the halogen series including fluorine thoramine chlorine bromine iodine and and if you understand the trends of these four class of compounds understanding the chemistry of main group elements will be much easier

so the classification is very simple let us look into the some of the features of p block elements and the properties how they change p block elements are essentially contain non-metallic elements and of course metals are good conductors of heat and electricity and in solid metals the electrons are extensively delocalized over the whole material that means the valence electrons whatever you come across in a typical metal they are not confined to the valence shell of that particular atom in the lattice they can freely move to the next atom that means you can assume as if a stream of electrons moving over the atom surface ah making them good conductors of heat and electricity and this property increases as we have more and more electrons in the valence shell and non-metallic elements in this context are essentially insulators and have no delocalizing bonding instead being formed from localized covalent bonds in the center of the p block there are

so called metalloid elements such as boron and silicon which show intermediate electronegativities they also show relatively low electrical conductivity compared to metals but this metallic property increases with temperature that means ah simply we can say in the periodic table if you look into the elements the non metallic property increases across a period and the metallic properties increases down the group main group elements can be roughly classified as metals with an electronegativity less than two as non metals with electronegativity greater than two point two as non metals that means main group elements can be simply classified as metals if the electronic tree value is less than two and as non-metals if they have electronegativity greater than two point two

so with this scale we should be able to classify the elements as metals and non-metals and in some cases metallites or semiconductors let us consider the first long period the change in properties can be nicely understood just by looking at the first log period starting from sodium and ends with argon and sodium and magnesium are both electro positive metals the next element aluminium is a metal but shows several characteristics of non metals in form many covalent compounds in group 14 carbon is a non metal whereas silicon is a metalloid and being a semiconductor and has compounds which show characteristics of both metal and non-metal compounds in group 15 of course nitrogen is a true non-metal and phosphorus is also a non-metal however phosphorus onwards the remaining elements are truly non-metals but with some metallic properties and if you look into the antimony and bismuth metallic properties increases and bismuth is a main group metal and in case of group 16 and 17 sulfur and chlorine are the true non-metals sulfur exists mainly covalent s8 rings and also in other forms or even also in higher ring form and chlorine forms diatomic covalently bonded molecules argon exists as a monoatomic gas under ambient conditions and does not participate in chemical bonding going to its field valence shell and very high ionization energy associated with it because of having s two p six electronic configuration

but when we go down in any of the main group elements become more metallic in character parallel by a decrease in electro negativity that means electronegativity can be directly correlated to the metallic properties as electronegativity decreases metallic property increases as electronic increases occur as a period non-metallic properties increases the properties of main group element compounds such as hydrides range from ionic in case of s block metals that means whether you make hydrides of alkali metals or alkaline earth metals they are essentially ionic hydrides exception with the beryllium which has covalent character because of the smaller size of beryllium and whereas in case of aluminum it is polymeric and rest of the hydrides of p block elements are essentially covalent hydrides the group one and group two elements are less electronegative than hydrogen that is nitrogen shows point nine whereas hydrogen activity is two point one

so the bonding are essentially ionic and they form compounds having composition MH because here alkali metal existing plus one state and hydrogen will be in minus one state these hydrides react very violently with water generating hydrogen gas and for beryllium and boron the electronegativity difference with hydrogen is very small and beryllium hydride is covalent and boron hydrides are also covalent clusters and of course here the formation of cluster is essentially because of the electron deficiency due to the configuration we have $s^2 p^1$ where sp^3 in order to form minimum bonds we are in charge of two electrons as a result boron hydrides form numerous neutral as well as ionic hydrides that we shall see in more detail when we look into the group 13 chemistry in group 14 the hydrates are all covalent molecular species typical of CH_4 that is methane similarly the group 15 16 and 17 element hydrides are all covalent molecular species and the acidity of these hydrides in aqueous solution increases on moving to the right as electro negativity difference between H and the element increases and the $H-X$ bond in case of halogens becomes more polarized and it will be a polar covalent bond having a δ^+ charge on hydrogen and δ^- on halides this has influence on the physical properties such as boiling point and other things those things we shall study in more detail in the respective group chemistry let us consider this problem here

so predict the properties of the hydrides found by elements with electronegativities 0.9 and 3.0 .

0.9 and 3.0 .

0.9 that means we have two elements of the main group elements having electronegativity value 0.9 .

0.9 and 3.0 .

0.9 and we know the electronegativity of hydrogen that is 2.1 .

0.9 if hydrogen interacts with an element with electronegativity 0.9 .

0.9 it has to be ionic in nature and similarly when the element having electronegativity 3.0 .

0.9 interacts with hydrogen and if hydride is formed that has to be covalent in nature

so you can see here the answer i have given and you have seen that the sodium has 0.9 .

0.9 electronegativity that means it readily forms a hydride of the type MH whereas in case of 3.0 .

0.9 it is chlorine it is essentially hydrogen chloride or HCl

so the first one is ionic hydride the second one is covalent hydride this is how this values will help you in understanding the nature of the bonding and also the properties of the corresponding compounds of main group elements like hydrides the properties of the chlorides follow a broadly similar pattern with fluorides of metals being ionic and of non metals being covalent molecules for

the group one and group two metals again except beryllium the chlorides are ionic solids which form neutral solutions in water the chlorides of small highly polarizing metal ions such as beryllium aluminum gallium and some other elements are polymeric in the solid state the majority of the chlorides of group 14 and 15 elements and bcl three or molecular covalent species the chlorides of the p block elements and beryllium generally give acid solutions in water because they readily react with it rather than simply dissolving in it and carbon tetrachloride unlike silicon tetrachloride does not react with water to give an acidic solution and this is purely kinetic effect i would tell you why ccl₄ does not react with water whereas sicl₄ readily reacts with water undergoes hydrolysis to form sio₂ through the formation of hydrogen chloride those things we shall discuss in group 14 chemistry let us consider the main group element oxides for main group oxides there is a similar trend from ionic oxides for the bottom left elements through polymeric oxides in the center many of which are amphoteric in nature two molecular covalent oxides for the elements of higher electronegativity on the at most right side of the p block oxygen is the second most electronegative element forms ionic oxides with group one and group two elements for example if you consider sodium oxide there is na₂o and calcium oxide cao which are basic oxides why we call it as basic oxide is when you treat the sodium oxide or calcium oxide with water they readily form highly alkaline solutions of the corresponding metal for example in case of sodium oxide we get sodium hydroxide in case of calcium oxide we get calcium hydroxide and hence the oxides of alkali and alkaline earth metals are called basic oxides

so that means sodium oxide when reacts with water it gives sodium hydroxide similarly calcium oxide when it reacts with water it readily forms very strong alkali solution such as calcium hydroxide one can also write as cao + h₂o → ca(oh)₂ are here two na₂o + h₂o → 2naoh group thirteen oxides such as boron trioxide and aluminium trioxide are polymeric and aluminium trioxide is amphoteric in nature any amphoteric oxide dissolves in both acidic as well as basic solution in group 14 the oxides of the lightest element that is carbon such as carbon monoxide carbon dioxide there is one more carbon oxide that's called carbon suboxide that is c₃o₂ are molecular oxides in contrast silica that is silicon dioxide is a polymeric oxide c₃o₂ is an acidic oxide since it dissolves in water giving an acidic solution that means electro positive metal oxides are basic in nature whereas p block element oxides are acidic in nature as they give acid solution when they interact with water in group 15 and 16 oxides of nitrogen are all molecular covalent species many of which are acidic while those of sulphur that is sulphur dioxide and sulphur trioxide both are acidic in nature or they are acidic oxides for example s₂o₃ when its reacted reacts with water it readily forms h₂so₄ that means it can also be simply shown as s₂o₃ + h₂o → h₂so₄ similarly group seventeen and group eighteen in case of group eighteen in only xenon they form oxides which are molecular species in nature let us look into the bonding concepts that are used for understanding the geometry and shapes of the main group element compounds in this effort in this process of coming up with some structure and bonding concepts to explain bonding in the main group elements the contribution largest contribution to start with came from gilbert newton lewis in 1916 he proposed the theory of bonding at university of california at berkeley and he added information about electrons in the periodic table and he also worked on purification of heavy water that is d₂o and also he proposed acid base theory and his contribution is immense in understanding the acid-base interactions that is the reason his concept is also known as lewis acid base concept and also he worked in the field of photo chemistry and in fact he was nominated 41 times for nobel prize and he was found dead on march 23rd 1946 in his laboratory at the time he was working with

hydrogen cyanide and some people thought that he has committed suicide however his life ended on a very sad note and he will be remembered as long as main group chemistry is practiced in several laboratories and his contribution is very immense in refining and coming with concepts to explain the geometry bonding and reactivity of all main group elements

so far we were discussing about the classification of elements and periodic properties under this title we learned several new terms that is electronegativity electron affinity or electron attachment and enthalpy and ionization energy and then electronic configuration

so p block elements and s block elements are essentially the main group elements and we have two s block elements having one electron in their valence shell they are called alkali metals having two electrons in their valence shell having alkaline earth metals and we have s two p one starting from boron to s two p a p six with neon that means having six groups of five each elements having s two p one two s two that is three to eight electrons in their valence shell and also we look into the relative sizes those size increases down the group and also atomic size decreases across a period and also electronegativity increases across a period and electronegativity decreases across down a group and similarly electro positivity increases down the group and some of these things if you remember understanding their chemistry would be much easier and for convenience all compounds of main group elements can be simply classified into four categories one is interaction of all main group elements with hydrogen the compounds are called hydrides these hydrides can be either ionic hydrides or covalent hydrides are having polar covalent property or non polar covalent properties and also they we will also come across metallic hydrides and with oxides again alkali metals and alkaline earth metals form ionic oxides and which are basic in nature whereas p block element forms oxides which are essentially acidic in nature and same thing is true in case of halides all main group elements interact with halogens to form the corresponding halides and these halides of alkali metal and alkaline earth metals are ionic in nature and they readily dissociate in water whereas hydrates of p block elements are covalent in nature

so some of these things we have understood and these aspects whatever understood will come very handy when we start discussing the chemistry of individual groups and before i proceed to the chemistry of individual groups i shall discuss on the structure and bonding concepts and how the structure and bonding concepts evolved starting from lewis dot structures to what we have today molecular orbital theory where we consider linear combination of atomic orbitals to arrive at very interesting molecular orbitals which can explain almost all properties of main group elements all these things i will be discussing in my next lecture ah thank you very much foreign