

uh hello i am dr ramesh ramapanikar i am an associate professor in chemistry at the department of chemistry at indian institute of technology kanpur

so today i will be discussing the portions that are covered in unit 10 of the chemistry book by ncert for class 12 students and ah this particular chapter as you would know covers halo alkenes and halo arrhenes these class of compounds are also known as alkyl halides and aryl halides they are a class of organic compounds where a hydrogen atom that is present in a hydrocarbon is replaced by a halogen atom multiple hydrogen atoms can also be replaced by multiple number of halogen atoms and in those cases two they fall under the same category however their ideal names are halo alkenes and halo arranes but you would find that the normally available and most common compounds are generally referred to as alkyl halides rather than haloalkanes however a systematic naming would require that we call them as halo alkenes we should start with the name of the halogen that is attached to the organic compound

so we will deal with the naming of these compounds and how these molecules are classified then we would go on to say how they can be prepared from simple starting materials and finally we will talk about their properties and then look at a few examples of these class of compounds that are useful to mankind either synthetic or which are available naturally now to begin with i would like to say that a general representation of these molecules that is whenever you would like to show an alkyl highlight that is a hollow alkyne by a simple representation the temp that we normally use is  $RX$  where  $R$  stands for the alkyl group as you already know and  $X$  stands for the halogen atom that is attached to the alkyl group and in organic molecules the most common halogen atoms that you would find are fluorine chlorine bromine and iodine and we will not see the fifth halogen atom the fifth atom that is present in the group 17 element astatine that is not normally found in organic molecules

so by halo alkynes we would only mean compounds of fluorine chlorine bromine and iodine similarly halo arrines are represented by a  $RX$  where a  $R$  stands for the aryl group or an aromatic group and  $X$  is the halogen atom in this case two here  $X$  can be fluorine chlorine bromine and iodine just like in the previous case now when we look at these molecules if we want to simply distinguish between an alkyl halide and an aryl halide by the simplest of possible ways the best method is to assume that an alkyl halide would have the halogen atom attached to an  $sp^3$  hybridized carbon atom that means the carbon atom would be completely saturated it will not be part of any double or multiple or triple bonds but a saturated carbon atom that is  $p^3$  hybridized attached to a halogen atom is often referred to as an alkyl halide or a halo alkane then in aryl halides they should be attached to an  $sp$  to hybridize carbon but most by the time an aryl halide or a halo arran we would mean that they are attached to an aromatic ring or a higher order aromatic compound

so we will look into these classifications and names in the uh coming slides okay

so before i go further i would also like to say that these kind of molecules are widely used by chemists and also by non-chemists even without knowing what these compounds are they one of the most common applications of these molecules us is that the lower members of this class of compounds are liquids

so they are used as solvents and they can dissolve most of the other organic compounds

so organic compounds unlike most of the inorganic compounds that we come across for example sodium chloride potassium iodide and

so on they are mostly non polar compounds they are not ionic

so such compounds needs to be dissolved in suitable solvents and haloalkanes are normally used as solvents for dissolving these non polar organic compounds

they also are highly useful as synthetic starting materials

so whenever we would like to prepare organic compounds that contain multiple functional groups one of the starting points for making these kinds of compounds are organo halogen compounds or haloalkanes or halo arrangements

so i would also like to say that normally these comp organic compounds that contain a halogen atom are called organohalogen compounds or organohalo compounds and

so on

so you would find these stems being used interchangeably in between or just to say that halogen containing organic compounds and

so on

so i have a few examples listed here

so you would find that these are also some of the examples that you would find in your book as being mentioned as organic compounds that contain halogen atoms

so first of them here is chloramphenicol

so this is an antibiotic this particular molecule is an antibiotic you can see that it has two chlorine atoms attached to this

so by antibiotic it is something that has antibacterial properties

so this can be used against bacterial infections that can cause various diseases

so this particular compound chloramphenicol is used against typhoid it is also a good against plague and

so on but it is one that is most commonly used against typhoid

so it has chlorine it has two chlorine atoms and you would also find that these chlorine atoms are attached to an  $sp^3$  hybridized carbon atom

so this is an example of a halo alkane the second example that i have is thyroxine

so thyroxine is a pro hormone

so this is not exactly the hormone that is functional you would find that it has four iodine atoms and all four iodine atoms are attached to aromatic rings now in the active form one of the iodine atom is lost from it and it would be a tri iodo compound that is the active and same and this particular enzyme is formed in our body and if you have a deficiency of this this is taken as a medicine this is taken orally

so this is just an example to show that this poly halogen compound the compound that hand contains as many as four iodine atoms attached to an aromatic ring is a biologically active compound and something that we produce in our body the third example is chloroquine this is used as a medication against malaria it is also used it is taken in advance to prevent from getting affected by malaria or it can also be used as a drug

so this has a chlorine atom that is attached to an aromatic ring

so although this as you see is a compound that has two rings attached but the chlorine is attached to one of the aromatic rings

so it is an example of a halo array

so the first three compounds that i showed you are having rather complex structures which are difficult to comprehend but you have a look at the fourth structure that i have here this just has two carbon atoms and the first carbon is attached to three fluorine atoms whereas the second one is attached to a chlorine and a bromine this is called halothane and this is a general anaesthetic

so these are given to patients before they are subjected to a surgery

so this compound would be able to make you not feel the pain or the medical process that a person is supposed to undergo

so this class of compound simply gives you an idea that the structural

diversity of these compounds are quite high and their applications are also quite a lot however while we are trying to use organo halogen compounds we should be aware of one particular fact that halogenated organic compounds degrade extremely slowly under natural conditions that means if it happens to go into soil if it happens to go into the environment they generally take quite a lot of time to get disintegrated or decomposed as a result they continue to stay in the environment and sometimes they continue to stay in living organisms and most of them can cause problems

so therefore although initially when halogen compounds started to be introduced for industrial applications they were widely accepted nowadays we would like to limit their usage because they could cause problems to the environment one of the reasons why they get degraded slowly is because the bacteria that are present in soil are generally not able to decompose them by their normal methods of decomposing organic compounds

so this retains these molecules in soil for longer time okay

so now the next thing that we can do is to have look at very simple examples of this class of compounds and then try to see how we can classify them

so that whenever we come across one of these compounds we are able to identify them and put them into a particular class and then able to understand them better ah from our perspective ok

so the most simple classification that we can have is on the basis of number of halogen atoms

so if you take first of all when you see an organic compound that contains a halogen atom we can have a look at them and see how many halogen atoms are present

so i have ethane molecule that is substituted with a halogen atom here

so this is a mono halo alkane by x as i have mentioned i mean either fluorine chlorine bromine or iodine

so this is a mono haloalkane one halogen atom is attached to it and the second one is a dihaloalkane i have put one halogen atom each on the two carbon atoms of ethane

so this is a dihalo alkane

so they are normally called as dye plus the name of the halogen atom and then the alkane that it corresponds to and the third one is trihaloalkane where i have three halogen atoms attached to three different carbon atoms of a propane based molecule the classification continues to be the same even in the case of aromatic compounds

so mono halo arene a compound that has only one halogen atom it can be dihaloarene when there are two halogen atoms present trihaloarene and

so on it has to be noted that these halogen atoms need not be the same

so whenever i write an x one of them can be a fluorine the other can be a chlorine the third one can be an iodine and

so on and all those compounds can be made and all the most of those compounds are known next we could go ahead and we can say that we should then once we know that once we have identified the number of halogen atoms present in a molecule the next thing to do is to look at the molecule and see where exactly is this halogen atom attached to the molecule

so based on that we could classify them as compounds that contain  $sp^3$  hybridized carbon atom that are those are saturated carbon atoms attached to a halogen bond

so this normally all the simple alkyl halides or halo alkynes that we started discussing with

so most of these compounds fall into this category and they as i have already mentioned are shown as  $RX$  and a general representation for this class of

compounds provided that there are no unsaturated bond within the molecule would be  $C_n H_{2n+1} X$  that this

so this is derived from the general representation for a saturated hydrocarbon which would be  $C_n H_{2n+2}$

so we have removed one of the hydrogen atoms and put a halogen atom the simplest example is a methyl halide or a halomethane

so i have methyl group here attached to an x now i have shown the carbon atom in blue color this is just because i would like you to concentrate on those particular atom that is attached to the halogen here and you can see that this carbon atom is attached to three hydrogen atoms that is when we call it as a methyl group

so it is a halomethane and the next example i have almost the same structure except that one of the hydrogen atom is replaced with an alkyl group then in the third structure i have replaced two of the hydrogen atoms with two alkyl groups and i have replaced all the hydrogen atoms with alkyl groups

so based on the number of alkyl groups that are attached to the carbon to which the halogen atom is attached these molecules can now be called as primary secondary or tertiary alkyl halides or halo alkanes

so once again these classifications are based on the number of substitutions that are available on the carbon atom to which the halogen is attached

so a primary halo alkane is one in which the carbon attached to halogen is bonded only to one alkyl groups and when there are two hydrogen atoms present we call them a secondary when two alkyl groups are present and tertiary when three alkyl groups are present the normal notation is simple notation if you do not like to write primary secondary and tertiary in all cases would be to use one with the degree sign on top but this should not be read as one degree and this should not be read as two degree three degree and

so on instead although you write them as one with the degree on top they have to be read as primary secondary and tertiary i quite often come across people who mentioned this compound as a one degree alkyl chloride two degree alkyl chloride and

so on which is not the correct way of calling them now even while i have said that these are compounds that do not have unsaturated carbon atoms attached to halogens we could also have these class of compounds which are called allylic halides where the halogen atom as you can see is attached to a  $CH_2$

so i would show you this particular carbon here which i know i have highlighted so this is a  $CH_2$  group it is attached to a double bond and an x

so this comes under the halo alkene class or this is an alkyl halide and here again the halogen atom is attached to a carbon that is  $sp^3$  hybridized however the same carbon is also attached to a double bond

so this kind of compounds where the carbon atom attached to the halogen atom is near is adjacent to a double bond are called allylic halides or allyl halides in general

so i have three such examples

so here you can see this is an open chain compound a linear compound where i have a double bond  $CH_2$  and x and the second example is where i have a double bond and on the

so it is a six membered carbon ring

so it's a cyclohexane ring

so in this cyclohexane i have a double bond

so it's a cyclohexene and on the carbon that is immediately after the double bond has a halogen atom

so this again is an allylic halide and in the third example i have a cyclopentene ring but now the  $CH_2$  that is attached to the double bond is going

out of the ring but it is attached to a halogen atom

so this again is an allylic halide

so allylic halides are those class of compounds where you have a double bond that is attached to another  $\text{CH}_2$  followed by an  $\text{X}$

so this all these out of these three structures you can see that this carbon is attached to one alkyl groups and two hydrogen

so this is a primary allyl halide whereas this one this carbon is attached to two different groups one double bond and this and there is only one hydrogen present in this

so this is the secondary allyl halide whereas this again is a primary allyl halide

so these are the classifications for allylic highlights they are all halo alkanes because the halogen is not attached to a double bond instead it is attached to a saturated carbon atom now the other class is benzylic halide

so these are compounds where the carbon attached to halogen is attached to an aromatic ring to be precise to a phenyl ring

so this is a primary benzylic halide or a benzyl halide where the aromatic ring is attached to a  $\text{CH}_2$  and an  $\text{X}$  and in the second example this carbon is also attached to another  $\text{R}$  group that  $\text{R}$  group can also be an aromatic ring it can be an alkyl ring two

so then we call it as a secondary benzylic halide and if there are two  $\text{R}$  groups and a phenyl ring we call it as a tertiary benzylic halide now again out of these two  $\text{R}$  groups either one or both of them can also be aromatic ring

so that does not matter we still call them as benzylic halide and they would be tertiary because there are no hydrogens attached to the carbon to which halogen is attached now we would go ahead and then talk about compound compounds containing  $\text{sp}^2$   $\text{C-X}$  bonds

so these are compounds where the carbon that is attached to the halogen is  $\text{sp}^2$  hybridized we started off our discussion by saying that aromatic halogen compounds or halo arenes or aryl halides are those carbons where the halogen atom is attached to an  $\text{sp}^2$  hybridized carbon atom but you already know that not all  $\text{sp}^2$  carbon atoms needs to be in an aromatic ring for example these compounds these two compounds here the vinyl halides

so this simply mean that i have a double bond and the carbon that is attached to the double bond involved in the double bond is attached to a halogen atom

so these are examples of vinyl halides they can be open chain compounds or they can be cyclic compounds now we call only those compounds as aryl halides where the halogen is attached to an  $\text{sp}^2$  carbon of course but to an aromatic ring the aromatic ring need not be benzene in all cases it can be naphthalene it can be any other higher order aromatic rings but as long as they are attached to the halogen atom is attached to an aromatic ring they are called aryl halides

so this is a very simple way of classifying these compounds ok

so now that we have talked about how these molecules can be classified we will look at their nomenclature

so you already know that once we know about a particular class of compounds we would like to give them names

so that whenever we would like to call out a name immediately a structure associated with the name comes to your mind

so this is the whole function of nomenclature

so the term nomenclature is given by iupac which you know is the international union for pure and applied chemistry

so now what iupac does what the union does is it sets out a set of rules based on which how chemistry should be seen and discussed by the class of people who follow chemistry

so one of their main criteria is to set out rules by which compounds can be named in a very systematic manner

so that the name that i am suggesting or i am telling is something that immediately the person who listens to the name is able to associate with a particular chemical structure

so all of the compounds that we see today can have an iupac name however some of the compounds were well established they were already known even before iups started setting out its roles

so such compounds are sometimes known more commonly by their common names because the chemicals are

so common that people would immediately identify them with name common names that were in use for decades

so based on this some of the compounds would have an iupac name and along with them they would have a common name now if you do not know the common name that is all right but you should always be able to write an iupac name for a compound but we would discuss the common names for the most common compounds and then discuss iupac name for most of the compounds that we would see here

so i have examples here to discuss the points with you

so the first compound i have is a halo alkene that is three carbon atoms and it is attached to a bromine atom by one of the sides

so just like the nomenclature that you studied in iupac whenever we see a compound what do we do first is we identify the carbon atom that has this particular substitution then we look at the compound and identify the longest carbon chain

so in this case it is a straight chain we do not have any issues with that

so there are three carbon atoms in this chain and it is attached to a bromine atom at one end

so the carbon that is attached to bromine atom is the one we would call as carbon number one

so this the compound has three carbon atoms

so it is a propane

so we would be able to call this compound as a bromo-substituted propane and the iups the name for that compound would be one bromopropane which means that we have a propane where the bromine atom is attached to the first carbon atom that means at the end of the chain now again this compound is propane

so it is called as normal propyl bromide in a common way

so it has a trivial name which corresponds to normal propyl bromide or n-propyl bromide

so you would also find this name being used

so what i have done is the red colors that i have drawn here are all the iupac names and the blue names are the common names

so it is always important that you know the upc names and you are able to write the iups names common names are not something which any any of us can start giving because those are already established names that were there

so if you do not know them that simply means that you are not heard about them but iupac names are something that we are able to give to a molecule even if we are seeing a molecule for the first time

so those are the names that one should practice and be able to give it to a molecule

so the second compound here

so this again is a propane but this time instead of bromine i have a chlorine and the chlorine is attached to the second carbon atom

so it is not at the end of the chain it is in the middle

so then what we do is we start numbering the carbon atoms from one of the sides

so we have one two and three and the chlorine atom is attached to the second carbon atom

so we call it as two chloro and then of course propane because there are only three carbon atoms in the chain

so the iupac name for this is two chloropropane the common name is even more interesting whenever you have a propane chain that is three carbon chain and if you put a substitution on the middle carbon it is normally called as an isopropyl group or this particular compound is called as isopropyl chloride

so isopropyl is when the substitution is on the middle carbon atom of a propyl group now the third example is isobutyl iodide

so you would immediately say that this has some similarities with the isopropyl group because i would show you three carbon atoms that actually looks like a profile and the substitution of a two i goes from the middle carbon

so that is why in common name it is called as an isobutyl group and this is an iodide

so we call it as isobutyl hydrate then again you see it is very difficult to give this common name by universal because there are no rules followed in here but whereas the iupac name is something that we can always give to the molecule

so now let us look at the molecule once again

so this is a molecule that has four carbon atoms and an iodide but you what we need to do is we need to identify the carbon that is attached to i and then make the longest carbon chain

so no matter which way you go you would see that you can only make a three carbon chain in this

so one of the methyl groups either this or this has to be seen as a substitution

so therefore the name of this compound would be one iodo two methyl propane this is because between the methyl group substitution

so if i am assuming that this is the chain that i would like to go with

so you see that i start with i ch<sub>2</sub> ch ch<sub>3</sub> and the second carbon atom has a ch<sub>3</sub> group and how do i name it is i give the name in such a way that the name that has the first alphabet in the alphabetical order that has to be that substituent has to be named first

so it has an iodine and carbon number one

so it is one iodo two methyl propane propane because there are only three chains

so it's a very simple rule but once we start using it we would be able to name it better now i have another example here this should be rather straight forward

so this is a four carbon chain with a chlorine at the end it is called one chlorobutane it doesn't matter which side you write chlorine chlorine can be written on this side or this side but as soon as you see a chlorine atom attached to an alkyl chain you number the carbon that has chlorine atom as the first one if chlorine is in the middle then that particular carbon should get the lowest possible number um as much as possible

so we will see that example

so this compound here is one chlorobutane and or its trivial name is n-butyl chloride or normal butyl chloride is a careful look at these names would suggest that while all the iupac names look like hollow alkynes the trivial names or the common names are corresponding to alkyl halides

so they name the alkyl group first followed by the halogen that is associated with as a halide

so these names also have more similarity with uh the inorganic compounds that we call sodium chloride for example where sodium is replaced with an n-butyl group

so so this this has a lineage from all the other chlorides that you would find in nature and different kinds of chemist used to use but whereas organic chemist would like to call them as one chlorobutane

so that their names are pretty clear to everyone who hears them okay

so this is one chlorobutane

so the second example here is more interesting because here i have four carbon atom but the chlorine is not attached to the first one

so now i can start naming this from descent or this end

so if i start naming it from the left hand side i would see that the chlorine atom is attached to the second carbon atom here but if i start numbering it from the right hand side i would find that chlorine is attached to the third carbon

so you should always start numbering from the side in such a way that the carbon attached to chlorine gets the lowest number

so this is two chlorobutane and not three chlorobutane

so we would always start naming from here butane because there are four chains two because there is the chlorine is attached to the second carbon chloro because it's a chloro

so if i replace chloride it would be with bromine it would be two bromobutane and

so on and this compound is its common name is secondary butyl chloride and sometimes return as s butyl chloride because uh here in butane the chlorine is attached to a secondary carbon atom a carbon atom that is attached to two alkyl groups

so it is called a secondary butyl chloride in its common name now the third one here is uh something that we have already seen it is similar to this compound here that i have the isobutyl iodide that we have already seen

so this is isobutyl fluoride it has to be named as one chloro two methyl propane

so that is the iupac name

so assume that you do not have any issues with this now have a look at the last compound i have on this slide

so this particular compound has rather interesting structure it's a carbon atom that is attached to three ch<sub>3</sub>s and a chlorine atom

so definitely this is a tertiary halo alkane because the carbon here which is attached to chlorine atom is already attached to three alkyl groups but to name this compound properly in ah following the upsc rules what we need to do is we look at the longest alkyl chain that has chlorine atom on it

so you can see that there is a ch<sub>3</sub> a c attached to cl and ch<sub>3</sub>

so once you consider this particular alkyl chain you would find that it has a ch<sub>3</sub> attached to the carbon that is attached to chlorine

so because the longest chain is only three carbon atoms it is a propane and the chlorine atom is attached to the middle carbon

so it is two chloro and the same carbon is also attached to a methyl group

so it is two chloro two methyl propane

so this is the way we would name it

so we would name this compound with the longest chain being propane we will call it as a propane with a chloro and a methyl substituent now which one to name first we would always name chloro before methyl because chloro starts with the c which comes first in the alphabetical sequence and methyl comes second because it has an m and the names the numbers have to be such that these substituents have the lowest possible numbers now i have other class of compounds

so we have left the simple halo alkenes there and we are going further and looking at these compounds that have double bonds

so see what you see here is an ethyne molecule

so you know all of you know ethyne is  $\text{CH}_2$  double bond  $\text{CH}_2$  now one of the hydrogen is replaced with a chlorine atom

so it is called chloro ethene and its common name is vinyl chloride

so there is no particular reason why it is called vinyl chloride the commons that are attached to a double bond a simple double bond are called vinyl compounds

so if it is a chloride we call it as a vinyl fluoride

so this is a common name all of you might have had pvc polyvinyl chloride which is a polymer that is actually obtained by polymerizing this particular common but that is a common name for the compound the iupac name is chloro 1,1

so it is ethene attached to a chlorine atom now i have a second example this is something we have seen this is an allylic compound is an allyl bromide but the iupac name does not allow you to call it as an allyl bromide instead what we would call it as is a propene derivative because there are three carbon atoms and a double bond and you would know that propene is the parent hydrocarbon here it's normal propane because there is a double bond

so propene is the parent hydrocarbon and the bromine atom is attached not on the double bond but on the carbon that comes after the double bond

so we would start numbering this molecule in such a way that the double bond gets the lowest possible number

so the double bond starts from carbon number one it goes to carbon number two and in the third carbon we have the bromine atom attached

so it is called three bromo propene or and we put a one in the middle just to tell you that the double bond is actually on ah not on the carbon that is bromine but once you measure three bromopropane it is pretty evident that the double bond is not exactly on the carbon that has bromine atom however a more appropriate way of numbering this would be three bromo prop 1 in 3 bromo propane is also fine now this compound this is something again what something we have seen this is a benzyl compound this is benzyl fluoride because benzyl group is attached to fluorine but the iupac name is quite interesting here because this has to be seen as a methyl group that is attached to a phenyl and a fluorine

so we call this as fluorophenyl methane it's not phenyl fluoromethane this can also be given a different name it can also be called called as a methyl fluoride attached to a benzene

so it is fluoro methane benzene is methyl benzene is another name for this but you can always see it as a methyl group attached to fluorine and a phenyl ring

so it is called fluorophenyl methane in iupac okay

so now we will go ahead and we look at polyhalogenated or dihalogenated compounds

so here i have ethane molecule that is attached to two chlorine atoms

so i am talking about the example here in the middle sequence the first one

so it is an ethane molecule that is attached to two chlorine atoms we call it as one one dichloro ethane this is just because the chlorine atoms are on the same carbon atom

so we give and when two substituents are attached to the same carbon atom we number it we give the number twice

so we say one comma one

so it is one one dichloro ethane and its trivial name is ethylenedine chloride

so it is ethylenedine actually comes from an concept that it is something that is similar to having a double bond because here we have replaced two hydrogen atoms

so these compounds are called as ethylenedine chloride in the common name

so something you would know only if you know the names by heart but whereas the upsc names are always something that we can give

so the second compound here is one two dichloro ethane

so this is an isomer of this the second compound is an isomer of the first one except that the chlorine has moved to the second one

so we say that it has two substituents on one comma two carbon atom and then it is an e then one two dichloro ethane and it is normally called as ethylene dichloride you know what ethylene is ethylene is ethane

so it is as if chlorine has added on to an ethene or an ethylene and two chlorine atoms are present on each of the carbon atoms of an ethylene to start with

so therefore we call them as ethylene dichloride in the common name these two compounds also have a very interesting name sometimes people refer to them as this one as a geminal dihalide

so by the time geminal what we really mean is that both the halogen atoms are attached to the same carbon atom

so then we call it as geminal dihalide if the halogen atoms are attached to adjacent carbon atoms close to each other then we say both these carb halogen atoms are in the vicinity of each other then they can be called as bisonal dihyalites

so these are two names

so this is a geminal dihalide this is a vicinal dihyalid

so you might come across these names being used in organic chemistry that only means that whenever you hear the time geminal which is the short form is gem gem

so that means that both the halogen atoms are on the same carbon atom and vicinal means they are on adjacent carbon atoms not too far away from each other but on adjacent carbon atoms the third example is a methane derivative two halogens are attached to methane it is called dichloromethane

so the iupac name is very simple we say chloro methane and if there are more than one chlorine then we add a prefix to that

so in this case die because there are two chlorine atoms

so it is dichloromethane and the last one is tri bromomethane because there are three bromine the trivial names for these two compounds dichloromethane is methylene chloride

so it is similar to ethylene because two hydrogen atoms are replaced with chlorine and the last one has a more interesting name bromoform and the corresponding chlorine analog is chloroform which you already know bromo foam and chloroform are also accepted by your upsc although they are not according to the strict rules of iupac naming they are term similar to benzene toluene and

so on which can be accepted okay now i have put the final example here

so that we can summarize all the points that we were discussing

so the commons that i have each of these compounds are pentine

so they all have five carbon atoms present in them but their iupac names vary if you follow the rules properly we'll be able to name them and they do not necessarily have common names

so these compounds are complex enough that they are not commonly named

so a person who wants to talk about this compound will not have a name that he can immediately remember and say

so they only have iupac names that we use but iups in names even if you do not know is something that you can give

so that is the advantage

so let us look at this molecule

so this molecule has a double bond and it has a bromine atom we said because the double bond changes the name of the compound the parent hydrocarbon is now known as a pentine it ends with an e n e not an a n e which corresponds to

alkanes

so it's an alkene

so the double bond should get the smallest number the lowest number possible

so we start naming from this end from the  $\text{CH}_3$

so that this particular compound gets the number two then the double bond continues to the number three and finally the bromine is attached to the fourth carbon followed by  $\text{CH}_3$

so you can see there is a longest aliphatic chain and that chain has a double bond between carbon number two and three and bromine is attached to the fourth carbon

so we call this compound as four bromo pentene because it has five carbon atoms pent two in because the double bond is on the second carbon

so this is called four bromopentene now let us look at the second compound here again there are five carbon atoms but if you look at this we would only be able to draw four carbon chains and this  $\text{CH}_3$  here has to be always seen as a substituent and we would name it in such a way that the double bond as i mentioned before gets the lowest number

so the double bond starts from one of the n

so we would start numbering one on the  $\text{CH}_2$  that has the double bond  $\text{CH}_2$  double bond and the bromine is on the third carbon and that is a  $\text{CH}_3$

so the  $\text{CH}_3$  which is here this has to be seen as a substituent

so this  $\text{CH}_3$  is a substituent here

so therefore when we try to name it we say that bromine is on the third carbon atom one two three third carbon atom then the methyl group is on the second one so it is three bromo two methyl and it is a butene because there are only four carbons in the longest chain

so three bromo two methyl but one in

so this one in would immediately tell you that the double bond is on the first carbon

so what is good thing with these iupac names is if if this compound is given to anybody and if anybody follows the ups you roll strictly they will all come up with the same name there is no even if the compounds are being seen for the first time they would be able to write a unique name following these rules similarly if this name is given to you and if you are asked to write a structure if you know iupac rules you will only draw one structure that corresponds to this molecule

so that is the interesting fact about this that is this is the exact reason why the international union for pure and applied chemistry that comes up with this set of rules

so that every compound every organic compound that we come across can be named uniquely and can be distinguished based on the name

so let us look at the last component to complete this

so this again has a methyl group as a substituent in a four carbon chain the bromine is attached to the last one but we would always have to name this compound in such a way that the double bond gets the smallest possible number so it doesn't matter if a number from here or from here the double bond is always starting from the second carbon then we would start naming it from the carbon that is attached to bromine because then the bromine substitution also gets a lower number

so this compound has to be named as one bromo and a methyl group on the second carbon one bromo two methyl but two in

so so this is the important thing if we start naming from the other end what we would name this as a four bromo three methyl butyne

so although the double bond is still on carbon number two the substituents

methyl and bromine goes on to carbon number three and four

so we should not allow that to happen we should always name it in such a way that these two substituents also get the lowest possible numbers as much as possible

so this has to be named as one bromo two methyl butane

so with this i will uh stop naming the aliphatic compounds the halo alkanes and i would go forward and start talking about halogenated benzenes

so all halo benzenes normally do have the same common name and iupac name

so so for some reason they from even before the iupac had set out the rules they always were being called as halo benzenes

so the simplest one here i have a bromobenzene here

so it is called bromobenzene in iupac as well as in common name

so it is never called as benzene bromide because you know benzene bromide is something else it is not even called as phenyl bromide or anything it is normally called as bromobenzene in the iupac nomenclature as well as in the common way of calling these molecules now if i have two bromine atoms again it is very simple in iupac you just number it in such a way that these two bromine atoms get the lowest possible number

so it is 1,2-dibromobenzene

so the only difference in common naming is

so you have learned the stems ortho, meta and para

so if the substituent is on an adjacent carbon atom you call it as ortho-dibromobenzene if it is one carbon away from each other then we call it as meta-dibromobenzene and if they are on one a one fourth position then we call it as para-dibromobenzene

so ortho, meta and para are associated with the common associated with the common naming pattern whereas one, two, one, three and one, four are the ways of naming these compounds in iupac now here i

so i have put an example quite intentionally here

so here you can see that there is a bromine atom and there are two chlorine atoms

so now how do we name them where do we start to name them

so if i call the carbon that has this chlorine as one then i have the second chlorine atom on two and the bromine atom on carbon number four but whereas if i start numbering from bromine then i would see that the carbon number one gets bromine then three and four gets chlorine

so although the first carbon in both cases are substituted the this the second substituent here

so i i would try to write these numbers here

so i hope you would be able to see them better when i do that

so what i would number is i'll call this as 1, 2, 3 and 4

so when i do that you are able to see that the substituents are on one, two and fourth carbon atoms now on the other hand if i go ahead and start numbering bromine as one

so i can also give this number here if i call this as one this is two this is three and this is four

so this is another way of naming it

so then bromine atom is on the first carbon then my second two substituents are on three and third and fourth carbon

so this is something that i don't want because then ah my numbers are going higher

so you should always name it in such a way that when you look at the number as a whole when you sum up these numbers you get the lowest possible number

so therefore we would name it as one, two and four substituted compound but now

what do we write first do we write chloro first or a bromo first of course we write first even if the bromine is a substitution on carbon number four we do not we do number that first we do not associate the number associated with uh with that particular substituent we only look for the alphabet

so in this case although bromo is on the fourth carbon atom it is b comes first in the alphabetical order

so therefore we call it as 4 bromo 1 2 dichlorobenzene

so this has to be the name any other name that you give to this compound according to the upc rules will be wrong okay

so now look at the last component that i have

so this is a compound that is a chlorine atom and a  $\text{CH}_3$

so we know a benzene ring attached to a  $\text{CH}_3$  group attached to a metal group is toluene

so toluene is also accepted is an accepted iupac name

so benzene toluene both these are accepted otherwise you can also call it as methyl benzene because iupac also accepts this name

so in this compound you see that you have a one chloro 2 methyl benzene

so you would name chlorine as one because chlorine in this case ah has the is the first alphabet that comes c uh always precedes them

so that is why we call it as one chloro two methyl benzene or it can also be called as two chlorotoluene

so it is toluene with the substituent one carbon number two however in the common system this molecule is a toluene molecule with a chlorine atom on ortho position

so it has to be called as ortho chlorotoluene

so this is generally about the iupac names and common names try to remember all the common names that you can means as much as possible if something that you see very often and if people refer to them by common names whenever you come across them it is ok to know them it is ok to remember some of those but even if you cannot it is not a big mistake because you are not supposed to remember all the names that you see you may have to remember a few of them like secondary butyl isopropyl isobutyl and

so on but other than that all the other common names are something that you may even skip but make sure that you are able to give a number proper iupac number to any molecule that comes your way

so you should be able to follow these rules and name them correctly your textbook has a lot of examples that your textbook has even some problems that are associated with this nomenclature of this compound

so i would suggest that you write them down and make sure that you are able to write all the upsc names possible ok

so now we have already discussed about how we can name this compound

so now you are able to give names to these compounds

so once we are able to do that the next thing is now we start really looking at the chemistry of this compound

so you see a organohalogen compound you are now able to identify this even if you are not able to identify you are now able to give a proper name to it

so that another person can listen from you about the component that you are talking about but the next important thing is now we start talking about reactions of these compounds and also about how these compounds can be prepared

so once you do not have a halo alkane you want to make them how do we make them so to know that it is always important that we know what exactly a halogen atom does to a carbon atom when it when it is linked

so of course you would have guessed that halo alkanes have different properties in comparison with simple hydrocarbons why are they different

so simply speaking a halogen atom is more electronegative than a carbon atom so whenever you have a carbon atom attached to a halogen atom it is no more like two carbon atoms attached to each other now we have a carbon that is attached to a more electronegative atom all the halogens group 17 elements are more electronegative than carbon

so what do they do is they try to pull electrons more towards them

so when a carbon and halogen atom are involved in bonding the electrons that form the bond are pulled more towards the halogen and away from carbon atom as a result as i have shown in this slide you will see that the carbon always feels slight positive charge because it has already contributed an electron for the bond but that electron is now has moved a little more towards halogen than carbon would have liked

so therefore now carbon has a slight positive charge and the halogen is happy to retain a negative charge

so if we want to draw this bond it may be even ideal to draw a slight positive charge which is normally represented by a small delta  $\delta^+$  and a delta negative  $\delta^-$

so the delta positive resides with carbon atom and delta negative resides with halogen atom

so this is to say that this particular compound now is polarized this particular bond now is polarized

so all organo halogen compounds are generally polarized

so they are these bonds are polarized

so these molecules have a dipole moment and the dipole moment as you know is normally measured in device in the unit d by ok now i have listed the methyl halides here

so the halomethane molecule

so starting with fluorine chlorine bromine and iodine

so i have ah fluoromethane chloromethane bromomethane and iodomethane on my table here and the left hand side column

so in this column you would find them and what i have in the immediately following column is the bond length

so you can see when carbon and fluorine are attached the carbon fluorine bond length

so these are given in picometers

so the carbon fluorine bond length is 139 picometers

so uh or 1.

39 angstrom

so you would find these bond lengths are increasing as you go down

so when you go from fluorine to iodine there is a large difference in the bond length this is expected right because bond length is exactly the distance between the center of the atoms that actually form the bond

so when you have a larger atom like iodine

so because iodine is very much lower down the group

so you would find that iodine is very big in comparison with fluorine

so therefore when iodine and carbon bonds together the bond is longer and

so so it goes sequentially

so the carbon chlorine bond is longer than the carbon fluorine bond carbon bromine bond is longer than the carbon chlorine bond and carbon iodine bond is longer than carbon bromine bond

so so that is expected

so this is the trend you would find now what about the bond strength which bonds are more stable

so you can also see that the methyl group when it is attached to fluorine the

carbon has a two  $sp^3$  hybridized orbital right carbon falls in the second period so it has its balance electrons in the second orbital so you would find that it is it has a two  $sp^3$  orbital that forms the bond and so is fluorine

so therefore these two are of similar size their orbitals are of similar size when

so therefore according to the very classical concepts of bond being formed by overlap of orbitals you would find that we actually have two orbitals that are almost the same size

so therefore their overlap would satisfy both the atoms that are involved so you get a bond that is pretty strong and the orbital overlaps are rather complete

so this results in an extremely strong bond and that is reflected in the enthalpy of formation of this bond

so you would find that 452 kilojoules per mole for a carbon fluorine bond whereas it comes down to 234 for a carbon iodine bond

so imagine iodine coming in with its big orbitals and whereas the carbon now only has a smaller orbital to offer

so whenever they overlap the iodine the overlap is not completely satisfactory so you would find that the bonding itself is slightly weakened and as a result you would always find that the bond energy of a carbon iodine bond is weaker than a carbon bromine bond which is bigger than carbon chlorine bond and the carbon fluorine bond being the strongest now what about the dipole moment there isn't much difference

so you would see that all the halogen atoms as i have mentioned are more electronegative and then there is this difference in patterns of bonding difference in patterns of bond energies and

so on

so ultimately the dipole moment is not much different they all fall in 1.8 near about except for carbon iodine bond because that is the weakest of all

so in this particular case uh

so iodine starts to be ah starts to get less and less electronegative

so in this case it is slightly lower then again it is not too low it's 1.

64

so all these carbon halogen bonds are polarized they all have dipole moment and comparable dipole moments except for carbon iodine bond which is reasonably lower than the others

so so this gives you a fairly good idea about how a  $CX$  bond is

so whenever you see that there is a halogen attached to a carbon immediately remember that the carbon is positively charged or in other words the carbon now is looking for electrons whereas the halogen is ready to leave with the negative charge it has already pulled the electrons from carbon towards itself a little bit now it is ready to leave carbon and leave carbon with a positive charge

so once carbon gets electrons from somewhere it would allow the halogen to leave

so so this this has a lot to do with the way organo halogen compounds or haloalkanes react

so we would come to their reactions later

so this is something that is that is worth remembering as we go along okay now since we have talked about all these things the next thing that i would discuss is about the preparation of halo alkanes

so how can halo alkenes be prepared

so the most simple preparation of halo alkane should of course be from the most available set of molecules

so the most easily available molecules are hydrocarbons right because they come from petrochemicals after that those are alcohols now alcohols are a good starting point for the synthesis of more many organic molecules just because the hydrocarbons are now already functionalized that is already a carbon oxygen bond

so if you want to functionalize an alcohol all we need to do is break the carbon oxygen bond and put the new bond then

so therefore this preparation of halo alkanes also do start from alcohols the simplest of them i mean

so now ah i have a very simple reaction written here the first one if you see i have an alcohol which is represented as an  $R-OH$  where  $R$  stands for the alkyl group  $O$  is for the hydroxyl group that results in the alcohol structure

so when an alcohol is treated with a hydrohalic acid hydrochloric hydrofluoric hydrobromic hydric and

so on

so when it is treated with the hydrohalic acid what do we get is a halo alkane plus a water molecule

so now if you would like to know how this may be happening why did this break what exactly happens is ah the hydrohalic acid dissociates right it dissociates in solution to  $H^+$  plus and  $X^-$  now this  $H^+$  that is present in any acid for example would like to interact with the oxygen atom of the alcohol and it would protonate the oxygen atom of the alcohol

so if you look at the alcohol here the  $O$  is already bonded to an  $R$  group and a hydrogen now if another  $H^+$  comes and binds to oxygen

so it is an  $H^+$  it does not have an electron it comes and binds with oxygen so the oxygen is protonated and oxygen gets a positive charge and because of the positive charge now this  $O-H_2^+$  group is actually like a water molecule

so what i mean to say here is that now your  $R-OH$  when you treat it with an  $H^+$  plus becomes  $R-OH_2^+$

so this or this particular group has retained a positive charge

so now this is something that would like to go out as water

so that leaves your alkyl group wanting a new group

so we already mentioned that hydrohalic acids are polarized

so i have  $H^+$  and  $X^-$  now when water leaves what does this  $R$  needs is something with a negative charge

so this would then react with the  $X^-$  that is present there and would give you  $RX$

so this is how alkyl halides are made from alcohols

so if you take an alcohol and put it with an  $HX$  hydrohalic acid we would get the halo alkane which i have shown here along with the molecule of water

so you would see that water comes out

so that is the simplest way of representing this reaction ah now but not all alcohols give you the reaction with the same is the general order of reactivity is tertiary reacting faster than secondary reacting faster than primary and methyl reacting the slowest now primary and secondary alcohols react with  $HX$  that is hydrohalic acids effectively only in the presence of zinc chloride as a catalyst

so otherwise the reactions do happen but they are extremely slow you may have to heat it you may have to leave the reaction for a longer time whereas tertiary alcohols would react immediately with the  $HX$

so so why is this different

so it it has some relation with the equation that i have written here i have shown that the  $O$  gets protonated and this  $R$  starts to feel the positive charge too

so generally the one that can hold this positive charge better

so the alkyl group that can hold a positive charge better would be the one that reacts better and you would later also see that tertiary alkyl groups are better in handling a positive charge better in handling an  $\text{OH}_2$  group leaving away from it

so that is the reason why it reacts faster but once you go into secondary and primary the reactivity therefore reduces now what exactly does zinc chloride does is zinc also has an affinity for oxygen

so therefore when you take zinc chloride which is a lewis acid it binds to oxygen even before hydrogen binds to it

so therefore it allows the breaking of the carbon oxygen bond and removal of the hydroxy groups faster

so that is why we use a catalyst in this reaction

so zinc chloride can help if the reaction is slow okay now sometimes you would have heard about hydrochloric acid you would have you would have gone to your labs and then seen that there are hydrochloric acids present in your lab in most of the labs in your schools but now some of the other hydrohalic acids are not commonly available we may have to make them in the reaction mixture

so one simple way of doing it is to take an alkyl alcohol like before and treat it with sodium iodide or potassium iodide sodium bromide or potassium bromide and

so on along with an acid

so if you are using sodium iodide to make an alkyl iodide all you need to do is you do not have to use hydroiodic acid you may be able to use a sodium salt of iodine and then put an acid along with this

so in this case you can use phosphoric acid

so what it would give is the alkyl iodide along with the sodium or potassium salt of phosphoric acid

so therefore you can also use an acid with the salt that might inside in situ in the reaction mixture generate the hydrohalic acid that you need a preparation of alkyl bromides is given here

so you take alcohol treat it with sodium bromide and  $\text{H}_2\text{SO}_4$  then we will get the alkyl bromide and the sodium salt of it plus water

so so this is a very simple way of making this molecule ok

so i continuing with what can be done with alcohol i will show you another example here

so if you take alcohol and treat it with phosphorus trihalide phosphorus has an affinity for oxygen

so it would be able to pull oxygen out of any molecule

so there are three halogens

so three molecules of alcohol can react with this and then give you a haloalkane along with phosphorus acid  $\text{H}_3\text{PO}_3$

so instead of using a hydrohalic acid you can also use  $\text{PX}_3$  and sometimes when the x is bromine or iodine you do not even need the phosphorous trihalide you can always make it in situ from red phosphorus and the corresponding halogen

so in that case you can take alcohol treat it with red phosphorus and the halogen and you would generate this  $\text{PX}_3$  species in situ and get this molecule you can also do the reaction with  $\text{PCl}_5$  if you want a chloride then the product that you get is  $\text{POCl}_3$  as the side product along with  $\text{HCl}$  and alkyl halide

so here again you can see that phosphorus pulls out this oxygen and  $\text{HCl}$  goes out and then one of the chlorine atoms goes and attaches with this the final reaction is the one with thionyl chloride and the most interesting because thionyl fluoride when it reacts with an alcohol gives you  $\text{RCl}$  then sulfur dioxide and  $\text{HCl}$  these two byproducts that are formed in the reaction are gases you will always end up getting the alkyl halide that you want

so in this case chloride because you are using tiny chloride  
so the along with the alkyl chloride or the chloroalkyne you get sulphur  
dioxide and hcl these two are gases  
so they escape from the reaction mixture and you end up having just the product  
you want  
so um to summarize what i wanted to say about the preparation  
so far this is the simplest stupidest synthesis possible you make them from  
alcohols you can treat them with that checks you can treat them with phosphorus  
halides or you can treat them with tiny chloride the one using carnal chloride  
to make alkyl chlorides is the most easy one to do because the by-products are  
gaseous  
so i would stop here for this class and then we will continue to discuss the  
preparation of haloalkanes in the next class thank you you