good morning yesterday we saw how to draw
leaves dot structures while drawing um leaves dot structures we consider particles
we consider electron as dots as a particles we given a dot for each electrons although
electrons are can also be electrons can also be a wave that you will be studying in quantum
mechanics
so we are going to see further um about leaves dot structures one of the concepts is the resonance structures what is resonant structures if you take a molecule for example ozone o3 it
is a allotrope of o2 which is present with o3 is present in atmosphere very small quantity but
it is present on higher in atmosphere and more quantity it is doing good thing for us but in
lower atmosphere it is doing bad thing for us apart from that we are going to see what is the
structure what is the actual structure of o3
so you can write leaves dot structure for this
molecule
so as as usual you have to find out what is the total number of valence electron first
so the valence electron equal to um three into the number of valence electron for each oxygen
atom which is equal to six
so that is equal to 18
so 18 is the valence electron
so you then
next step next step is the ah choosing the central atom
so here
so the only one type of atom
is there
so underlying the central atom must be the oxygen itself
so whoa whoa whoa arrange the
atom first around that central atom and then draw a single bond then that's drawing two single
bonds consumes four electrons
so you have to subtract that four electron from the total valence electrons
so minus four equal to remaining 14 electrons these 14 electrons should be distributed
among these three atoms in such a way that each atom at times eight electrons
so let us see
this way this way this way and then this way this way this way
so far we consumed tall electron
remaining two electron can be added to the central atom because the thermal atom this
these two are terminal atom which already now assigned okay we as as we assigned at times
eight electrons
so the remaining two more electron can be given to the central atom okay now see
the um um total number of valence electrons that was given to the structure and

so that should
match with the valence electron counted before
so here's there are six three lone pairs that
six electron three lone pair six electron one lone pair
so that means 12 6 plus 6 12 plus 2
14 and then two bonding electrons
so um 14
so that is a 16 this is 18
so total number is 18 is coming
all right
so the number of valence electrons are given to that and it is matching with the what is
what was counted before now if you look at that um whether um all the atoms attained um octet
or not it is not only the terminal atoms attain um octet that is eight number of electrons
are around that that thermal atom now if you look at the central atom it has only six electrons here
two here is two here is the two
so six electron then what you can do is you convert the lone pair
on the um lying on the adjacent atom towards that central atom
so that you can do by drawing like
this
so you can write o double bond o then single bond single bond
so since you um since there are
a pair of electron was pulled towards this oxygen atom then it is left with only remaining two more
pair of electrons that you can draw like this okay and then retain this lone pair
here and retain these three lone pairs as such now if you count the number of electron
around the central atom it is eight because two two two two eight now about this one eight
about this one is eight
so this is the optimum
so this is a actual living structure
so now the
leave structure is drawn this is the leaves such as leave is dot structure you can call
that as a dot structure or leave structures leave structures now the same way what i
did um is pulled one lone pair of electron from the atom lying on the left side you
can also do the same way for the from the right side atom
so you can also
pull this lone pair of electron um and convert it into a double bond then you can draw a structure ah of this type that is o o and then double bond o two lone pair
two lone pair and then here it is three because you pulled only this one and this remains
these two remain same and there is seven now you can see the number of electron around the
each oxygen atom it is eight here is eight here again it's eight
so now if you look at

it these two structures that is structured for example this is structure a this is
structure b both structures are equivalent because they are correct leave structures
however the question is what is the actual structure for o3 that is a question to be
addressed
so these two structures differ only in the allocation of the electrons that means
you
so on right side you give more electron for for for one structure for another structure
you give more electrons rights are on the right side then accordingly the bond pattern will
change
so these two structures differ only in the allocation of electron it can be one electron
or two electron but they differ accordingly when the allocation of electron is changed the bond
pattern will change but they are levy structure
so these two section now i am going to call this
as resonant structures ok these two structures are correct leave structures but actual structure
is not this one
so this
so these two structures are called resonance structures which can be represented by this type of double pointed arrows double pointed arrow or double headed arrows
you can call it that
so these two structures are equivalent and which differ only in
the allocation of the number of electrons
so which are represented which are connected to
each other by this type of arrow that is called double headed double headed or double
pointed arrows
so now the question is i am ok which is the actual structure whether
this is the correct structure for that o3 or this is the correct structure actually
none of them is the correct structure which is surprising then what is actual structure
we have to ask that question the actual structure is um a blended structure of these two
sections actually a and b are mixed to give you a resonance hybrid structure ok so
the blended structure can be written like this like that now you can see that okay the blended
structure represents um a dotted line
so three oxygen atom a single bond and then you have a
dotted line that dotted line in indicates that a partial bond
so ok partial bond
so this
structure is called resonance hybrid structure this structure can also be called these
two these two structures thats actually a and b can also be called canonical

structures that means these are the such which are
these are the such ah structures which are imaginary structures okay
so we imagine one
structure to understand the actual structure so
so it is not the structure it is
existing
so it is important to keep in mind that none of the structure never
existed in reality at any time the ocean has either either this structure or
this structure
its actual structure its actual structure is a resonance hybrid of these two
structures is
a blended structure of these two structures because
so the concept here is the resonance
or canonical structure because if you draw one level is that structure it is
not correct
correctly telling the actual structure of the actual electronic state of the
actual ground
state electronic side of the o3 but if you combine these two structures you
could you could get a um
hybrid structure which is called okay which tells uh which gives better
explanation about them um
about the accidentally observed bond distances if you go by these structures
you will see that ok
if you go by this structure there must be a double bond and here there is a
single bond ok
so double
bond distance of shorter compared to a single bond distance
so accidental what was observed is
for o three o three the over distance equal to 128 picometer if you consider
actual typical volvo bond distance equal to 148 picometer
typical over double bond distance equal to 121 picometer now the actual the
excellent observed overbound distance in o3 is 128 picometer which
lies between these two values
so so that means it is not a single bond it is not
a double bond this it is in between okay
so the bond order is bond order the concept we will see
later on
so bond order is one and a half
so soon
so you can see here here it is the bond
order is 1.
5 the bond order is 1.
5 that's why it's its distance over distance is 128
picometer it's not single bond or a double bond now one more thing is that what
i drawn for o3
is a linear structure okay this structure these two structures are correct as
far as lewis dot
structure is concerned but actual structure of o three is not a linear it's a
bend actually it's
a bend o like that its structure is like that now
so actual structure you cannot get actual
geometry of a molecule you cannot get by drawing a leaves that structure it
gives only how what
what is the link where is the lone pair located and what is the pattern you

can get but you
cannot get what is a geometry of that molecule for example if you take for ah another example is
the b of 4 minus you can calculate the number of valence electrons and then you can do the leaves
dot structure and it will come out like this and then you have to put the overall
charge this means overall charge of the species now you can see that what i drawn here
is a planar molecule actual structure of this tetrafluoroborate is a tetrahedral it is a planar
circuit
so actual this is actually a tetrahedral geometry
so you don't like leave structure
does not give what is the actual structure it gives information about how atoms are
linked where is where are the lone pairs and or in other words is a bonding pattern you can get
so resonant structures we can
also see um with more examples for example what is some lewis
dot structure for no3 minus no3 minus as usual you can calculate number
of valence electron n plus three whoa okay 3 into o plus minus 1 the for minus 1 you
have to add 1 electrons
so that is one has to keep in mind whenever there is a positive charge
on a species that means one electron is less okay whenever there is a negative charge one
electron is more which is to be added uh to the actual valence electron
so no3 minus okay minus
means one electron that is to be added to the total valence electron count
so in the
so as as
usual the valence electron of nitrogen is 5 plus 3 into valence electron of oxygen is 6 plus 1 okay
so that comes what is certain 21
so yeah 18 19
so 24 electrons
so 24 valence electrons came out
that can be arranged around this nitrogen molecule no3 minus
so then you can draw a structure um as
usual n o o o like that
so there are six electrons are consumed to write three single bonds
so six
minus six it gives
so eighteen valence electrons that weighting electron can be distributed around
the terminal um atoms then you will see like that like that now there are six six six eighteen so
eight electrons are over and then you have to give you the overall charge overall charge now um
if you look at the central atom that is nitrogen atom it has not attained the octet then what you
have to do is you have to convert the lone pair into a double bond
so you pull this lone pair here

and then see nitrogen o ok double bond here here o ok
so after pulling one lone pair it has only remaining two lone pairs here nothing happened as such as such here again then you have to put the overall charge minus same way you can write okay you can also pull this lone pair and you can write another structure like that overall charge is negative same way you can also pull this lone pair to give the nitrogen atom octet of electrons and then overall charge is negative
so now you can see that ok there are three structures can be written okay for a no3 minus
so that means these three structures are called resonant structures which can be represented by a double pointed arrows there are some structure the resonance hybrid structure is this one which are shown as a dotted line and the overall charge is negative
so you can see that the double bond can be here or here or here or if you take this one okay double bond can be here can be here it can be here that means all three structures are equivalent and they are contributing to the actual ground state electronic state of no3 minus
so that's why these structures are resonance structure or canonical structure or imaginary structure you can say that because we designed the structure to understand the actual structure
so that's why it is imaginary structures but you have to keep in mind that it never existed at any time for no three minus but it is used to understand the actual electronic structure for that purpose only if you go for a quantum mechanics that we may be seeing later on that actual structure of the no3 minus is um is a combination of this structure this wave function of this structure wave function of this structure and wave function of this structure and then you will get um net wave function and its energy will be lower compared to the contributing structures
so these structures also called as a contributing structure how much they contribute that depends on the actual um structure it is not necessary that all resonance structures should contribute equally some may be contributing more some can be contributing less but they are contributing to some extent to the actual structure
so depending upon that one can find out from the quantum mechanics so so these are all contributing structure to the actual structure which is used to understand the actual electronic ground state structure now as a result the bond distance or average you see in the blended structure the bond is sensor average it is not a double bond or it is not a single body it is in between that we saw before same way
so another important thing is that

if you take this molecule or any one of these okay now you have to give a formal charges
now we are going to assign formal charges how to assign a formal charges
formal charge fc equal to number of valence electrons minus number of electrons in unshared pair minus of electrons in bonding pairs pairs divided by two which is very important
so you first you take here what is the find out what is the valence electron of
the atom suppose you want to assign um what is the charge formal charge for an atom
then you should first take up the valence electron we are all concerned about valence electron
because it is those electrons are involved in reactions rearrangement of those valence electrons
are responsible for reactions
so its reactivity is coming we are more are okay mostly concerned about valence electron we are not concerned about inner core electrons which are intact which are lying
inside they are not involved but we are concerned about the valence electron because which are okay
which are responsible for forming new bonds or cleavages of the bonds
so you take a well select
on you from that you subtract number of electrons present in in lone pairs or that is called
unshared pairs okay suppose your lone pair is the number of electrons two not one okay
so that
is why the number of electron in unshared pairs minus number of electron in bonding pass okay
there is a bonding pair that means each bond is consisting of two electrons
so so that you have to
then that two electrons should be divided by two suppose number of bond is two then the number of
electron for calculating num formal charge is one ok number of bonds is three then three into two
equal to six six divided by two gives three so that value will be here this value will be three
like that
so that will become very clear when you see a actual structures actual some calculation
for formal charges now this type of formal charge calculations are applicable only if the bonds
are pure covalent bond okay covalent bond means a share of electron is a pair of electron is shared
between two atoms and they are equally distributed okay and the assigned lone pairs are located on
that particular atom only ok
so these conditions should be there to calculate formal charges
so now
let us see few examples how to do a formal charges if you take ammonia ammonium cation like that now hydrogen has two electron b gas
around this hydrogen atom only two electrons which is that the hydrogen is satisfied with the
two electron because it has only the capacity of accommodating only two

electrons
so but nitrogen
around nitrogen there are eight electrons correct one two three four
so four into two eight
electrons are correct now the charge what is the charges
so the overall charge ammonium cation
is plus
so where is the charge whether it is a hydrogen atom or or at the nitrogen atom that
we can calculate if we calculate formal charge for the nitrogen how to come we can find out
that for nitrogen okay then the number of valence electron for nitrogen is some phi minus this minus
number of electrons in unshared path there is no there is no lone pair electron or unshared pair of
electrons on this nitrogen atom
so it is zero here minus this minus number of electron in bonding pairs divided by two
so around nitrogen there are four bonds okay
so there are four bonding pairs
are there
so four bonding pairs means four into two eight eight divided by two equal to four okay
that comes comes out to be plus one
so that is uh that is why charge on the nitrogen is plus one i
hope this is clear how to calculate this type of calculating the formal charges is very important
when you write mechanism for organic reactions okay otherwise you will end up with wrong may
be um in the thinking that wrong nucleophile attacking electrophile instead of saying
nuclear this atom as a nucleophile you will say that as a electrophile like that
confusion will come if you have not written actual leave structures with formal charges now
so let us see for no3 minus there we found the overall charge is minus but if you look at any one
of them leave is dot structures for example here here now the here there are two electrons
here there are two electron there are three lone pairs here on this this is the
overall charge is minus how overall charges came out to be a minus one that we can find out
so the overall formal charge is m summation you see some of the formal charges on each atom so
if you do um formal charge calculation for each atom then you will see that what is the formal
charge overall formal charge for that species now for nitrogen if you do calculation nitrogen is
valence system phi minus number of lone pairs on the nitrogen atom number of electron in the lone
pairs there is no lone pair
so that that means you can give zero then the number of
bonding electrons here there are four bonds one two three four okay

so four
bonds that is eight by four equal to that is four sorry here it should be
minus okay
because minus minus
so valence electron minus number of electron in unshared electrons minus
number of bonding electron divided by two so there are four bonds that means
eight electron
divided by four two equal to four
so that gives that gives charge of plus one sorry plus one
that's correct
so it is a charge of plus one okay now let us do a calculation for this one
the
valence electron for oxygen atom is six okay minus lone pair of number of
electrons in lone pairs
there are three lone pairs
so one two three four five six six then number of electrons in
bonding divided by two only one bond is there between these two exam these two
atoms
so by two
equal to ok one ok minus one
so that is equal to this six six are equal to minus one okay
similarly if you do a calculation for this auxin atom it is six minus lone
pair of
electron one two three four four minus number of bonding electrons these are
two bonds
four electron by two two ok it is equal to zero now if you do calculation this
is same as
this atom
so you can right away assign minus 1.
now you can see that here is some minus so
here is the zero formal charge here is some minus 1 here is minus 1 okay you
add them
minus 1 plus minus 1 okay and then plus 0 here plus plus 1 okay minus 1 minus
1 0 then
plus 1
so you can see that minus 1 plus 1 then you end up with minus 1 only so
that is why we are putting minus 1 clear
so we saw what is formal charge
now let us see another example and which is a little bit difficult one what
about n2o you can calculate the valence
electron 2 into n plus o that is 2 into 5 plus 6 okay
so 2 of 10
plus 6 16 valence electrons now you can find out the central atom here
the least electronegative are the atom with more bonding capacity bonding
capacity refers
to the presence of number of unpaired electrons okay that is a bonding
capacity
so nitrogen is the central atom because there are any of two nitrogen atoms
are there you can write nitrogen nitrogen wove
so there must be one single bond for connecting or
linked to the central atom
so four electrons are gone minus four equal to twelve valence electron
that total balance valence electron you can assign around this um thermal
atoms terminal

atoms here and here here here here here okay
so now the count the number
of valence electron around this okay
so 6 plus 6 12 plus 12 okay 12 14 16
that is a valence electron calculated before it's matching with that one but if you look
at the number of electron around this nitrogen atom you see it similarly around this oxygen
atom is eight
so it is okay but if you look at the number of electron around this nitrogen it is only four that is two here 12
so only 4 electrons are that is not obeying which is as
up now it is not obeying the leaves octet rule
so what you have to do is you have to pull
this lone pair here and then you can write restaurants like another structure and then see
whether it is um whether it has eight electrons like that now you see here e there is no problem
with this nitrogen there is no problem with this right now because there are eight electrons
but around this nitrogen atom only six electron because two plus two plus two six electron that
means it requires two more electron from somehow from adjacent atom
so that it it will be
happy
so what you have to do is you take you take away you pull this lone pair to this one and then you can have like this now you can see that around this oxygen atom eight electron around these nitrogen atoms
eight electron around these nitrogen atoms eight electrons
so this is an actual this actual
leave structure this is the leave structure when the central atom is attained the octet
then writing the leaves dart suction is over now you can see that this structure now you could there are other way
you can write the same structure let us write this one n here like this now you can also um pull electrons
towards this towards this oxygen atom
so you pull electron here okay and then this here
then you can write this structure like this which is i'm going to call
this as as a resonant structure okay after taking away one lone pair from this
nitrogen atom there is only one lone pair on this and then it becomes triple bond then hydrogen
then it becomes single bond because this lone pair is changed to a sorry this bonding
electron pair is changed to a lone pair like that now still if you look at the structure
of number of electrons shared by each atom is eight
so here there are eight electron two here
two two twos eight if you look at this nitrogen atom there are three bond three bonds here
one bond
so eight here three lone pairs one bonding pair
so eight

so this structure is also a
correct structure correctly dot structure you can also pull the lone pair electron in the opposite
direction you can pull this here okay and then convert this bonding pair into a lone pair then
you can see that another structure this way also you can you can write nitrogen um three lone pair okay it becomes single
bond and then nitrogen and then it becomes triple bond okay and then you are left with a lone
pair
so from this structure what we did is taken away the lone pair from this oxygen then it becomes triple bond ok and then this this bonding pair is changed
to a lone pair then it becomes a single bond and you can see the structure like that you can
write now you can see that this structure also correctly with that structure but they are all
called resonant structure or canonical structure or imaginary structure contributing to the actual
electronic ground state of n2o among these which is the most contributing structure how to find
out one can also find out the most contributing structure to the electronic ground state structure
based on formal charge actual okay
so you can also find out how to okay which is the now the question
is which is the best structure or which is the are on the structures which is contributing to
the contributing more to the actual structure which can be decided based on as well
okay from based on formal charges let us see that then to find out what
is the actual structure then you have to follow certain rules okay for to select the base structure to select structure to select the base structure you have to follow the following steps the structure with formal charge of zero is preferred is prefer formal charge the structure with the
formal charge of zero that means if you among if there are more than two some more than
one structures in then you have to choose a structure with which has no charge
so that means
the charge should be equal to zero
so there should be no charge plus one minus one like that there
should not be any charges on any other atom that structures are preferred structures
so that is our
first condition the second one is you choose a so if there is no such such such as carrying um zero
charges then you have to go for another structure which is carrying the charges which is which
are closer or closer to closes closest to zero that i will explain later on okay if this
if there is no structure with zero formal charge then you have to go for a structure
with formal charges its value is equal to 0 or closest to 0 that would be the preferred
structure the second condition is that choose negative charge should should be

on atoms or atoms should
be on atom of more or most electro negative element
so that would be the next
condition for choosing them on the best structure contributing to the
actual structure now if you look at the these three molecules now you have to find out the
formal charge for all of this when you do a formal charge for all of them you will find that it is
minus 2 here you can calculate i am giving the right away writing that formal charges from
already i worked out plus 1 this is plus 1 now on charge on this one is a plus it
is minus 1 this is a plus 1 this one is 0 and here you have 0 and then here you have um okay plus 1
here you have minus 1 correct
so this is a minus 2 because in addition to lone pair there
are two more electrons are on this nitrogen atom because our nitrogen balance is three okay so
apart from two valence electrons lying on there it has two more electrons
so it is two minus
if you look at this nitrogen there must be a lone pair of electron lying on the nitrogen
atom then it becomes zero but the lone pair is bounded here
so it is a plus one okay then if
you look at this one okay the lone there must be two lone pairs on each on oxygen atom on this
oxygen or atom but there is only one lone pair the another lone pair is consumed for forming a bond
so that means plus one here that's correct now now if you look at the same way with this minus
one because one one electron is acquired by this nitrogen atom this is plus one and then this
one is correct because there are two lone pairs and this oxygen atom is zero okay now if you look
at this one is a lone pair on the nitrogen atom
so three balance is three
so it is correct
zero but if you look at this a lone pair is is used for forming a bond so
plus one but if you look at that this oxygen atom carries one more lone pair
so it
is minus one that's correct now among these three structures which is the actual structure now when
you compare the resonance structures for no3 minus here it is all these three structures are
equally contributing and they are equivalent all three structures are equivalent okay and like
this same rational structures for n o to minus is not equal they are three different structures
but which is the actual contributing we are among this which structure is contributing
more that you can decide by following the formal charges then you have to look for a
structure with the um formal charge of zero but you cannot find any structure with the

formal charge of zero because there is a charge here is a plus one minus one here is a
plus one minus one here also minus two plus one
so all these structures carry some charges so
then we cannot decide based on that then you go for um okay relax the rule little bit
so go for
a structure with with with the formal charges equal to zero are closest to zero now if you look
at that the formal charge on is minus two but here minus one plus one here minus one plus one so
which are closer to zero compared to this one
so these two structures we can um choose among
these two structures okay among these two sides for example this is a this structure b among
these two structures which is most um contributing structure that you cannot decide um based on the
the second rule that is the negative charge should lie on a atom which is more electronegative
so if you look at the here the charge on this oxygen atom okay between nitrogen
oxygen oxygen is more electronegative than nitrogen
so the formal charge on this oxygen atom
is zero if you come to this structure the formal charge is minus one
so the negative charge lies
on electronegative oxygen atom
so this structure is some most preferred structure
so structure b is
the most preferred structure is the most preferred preferred structure now in fact it is found experimentally
that its a if you look at the bond distance ok no no
so if you look at the bond distance
bond length between n and atom lies between double bond and single bond similarly if you
look at the bond distance or bond length between n and o it lies between single bond single
bond and double bond
so that those are the facts um found extremely matches with what
we expect based on lewis dot structure now let us see few more examples if you take a molecule such as p f phi and then s f six then you can draw a lewis dot structure for this like this p five bonds like that ok i just drawn approximately structure its actual geometry is a trigonal bipyramidal
which i have not written here because you can draw lewis dot structure as such now and then you
see that you can put lone pair here here like this and this you can also do a calculation
phosphorous atom belongs to them um fifth group elements eight
so number of valence
electron is five okay plus um okay phi into um seven because the valence electron for
fluorine atom is seven
so that is um um 35 plus five equal to forty valence electrons okay
so now that valence of 540 electron
you can find by counting this um electrons from here there are five bonding

electrons so
phi into two equal to ten electrons there are three lone pairs on each fluorine atom so
3 into 2 into there are 5
so phi equal to 30
so in total 40 valence electrons
so the
total is matching with that now you see here the terminal atoms that is the fluorine
atoms at times each fluorine atom attains the octet octet of electrons but if you look at
the number of valence electron which you shared with the um terminal fourin atom by pass press
atom is ten see that two two two to two
so so it has ten valence electrons
so it is more than
octatop electrons that means phosphorus requires more than octet of electrons in this molecule so
these compounds are called hypervalent compounds another example is this one there
also you can write similar structure equine right now if you look at the number of valence electrons shared by sulphur with the with neighboring fluorine atom is 12
so sulfur has 12 valence electrons
so it exceeds octet rule
so these two compounds are called hypervalent compound because if the valence is high proof
that's why it is a hypervalent compound the balance actually as per the fifth group elements
okay it should um obey the um leaves dot structure or octet rule but octet rule is not obeyed here
the number of valence is on the valence electron around this sulphur atom is stall for this pass
plus compound it's it's five okay it's a ten so the number of balanced electrons exceeds octa two
so these compounds are called hypervalent compound and it should not be confused with
so for two
minus for this molecule you can write a structure this is like this you can write a structure you can write a structure this minus this minus this is zero okay formal charge on this is zero here it is if you draw the structure here it is zero now
if you count the number of electron around this sulphur atom is okay
so one two three four five
six six into two twelve twelve valence electron but it is not um okay hypervalent compound okay
so it's a extended um octet rule okay extended its octet um rule
so to okay this structure is drawn
such that if you draw a another molecule
so to avoid the higher formal charge you will drawn this structure
so this structure you can draw from here now the formal charge and this alpha atom is
2 plus this is minus okay and this is minus this is minus this minus

so the overall
charge is okay 2 plus this overall charges overall charge is two plus
so the on this
sulphur atom it obeys octet rule okay because there are four eight electrons
around this alpha atom but it carries long two plus charge higher charges to
avoid
that we can write like this type structure it does not mean that sulfur does
not
not obeying the octet rule thank you you