Chemical Bonding

To design such a molecule researchers used bonding theory-models that predict how atoms bond together to form molecules . Bonding theories are central to chemistry because they predict how atoms bond together to form compounds and what combination do not . For example , bonding theories predict why salt is NaCl and not NaCl2 and why water is H2O and not H3O . Bonding theories also explain the shapes of molecules , which in turn determine many of these physical and chemical properties . The bonding theories you will learn lewis theory. In this theory we represent electrons as dots and we draw what are called dot structure on lewis structure to represent molecules .

Representing valence electron with dots :-

In lewis theory the valence electrons of an element are represented as dots surrounding the symbol of the element , the result is called a lewis structure , for example the electron configuration of

O is 1S2 2S2  2P4 ← 6 valence electrons

And the lewis structure is :-

∙O: ← 6 dots representing valence electrons .

The lewis structure for all of the period 2 elements are

Li ∙ , ∙Be∙ , ∙B∙ , ∙C∙ , ∙N: , ∙O: , :F: , :Ne:

Lewis structures allow us to easily see the number of valence electrons in an atom . Atoms with 8 valence electrons which are particularly are easily identified because they have eight dots , an octet .

Helium is somewhat of an exception. Its electron configuration and lewis structure are : 1S2  He:

The lewis structure contains two paired dots (a duet ).

For helium aduet represents stable electron configuration . In lewis theory , a chemical bond involves the sharing or transfer of electrons to attain stable electron configurations for the bonding atoms . If the electrons are transferred , the bond is an ionic bond . If the electrons are shared , the bond is a covalent bond . In either case , the bonding atom get stable electron configurations . As we have seen , a stable configuration usually consists of eight electrons in the outer most or valence shell . This observation leads to the octet rule :

In chemical bonding atom transfer or share electrons so that all obtain outer shells with eight electrons . Hydrogen , Lithium and beryllium are exceptions to the octet rule , Each of these achieves stability when it has two electrons in its outer most shell .

Q- Write a lewis structure for P , Mg . [15,12].

Lewis structures for ionic compounds ; Electrons transferred when metals bond with non metals , electrons are transferred from the metal to the nonmetal . The metal becomes a cation and the nonmetal becomes an anion . The attraction between the cation and the anion results in an ionic compound . In Lewis theory , we represent This by moving electron dots fro the metal to the nonmetal . for example potassium and chlorine have the fallowing Lewis structures .

K∙ :Cl:

When potassium and chlorine bond , potassium transfers its valence electron to chlorine .

K∙ + :Cl:

When potassium and chlorine bond , potassium transfers its valence electron to chlorine .

K∙ + :Cl: → K+:Cl: -

The transfer of the electron gives chlorine an octet (shown as either dots around chlorine ) and leaves potassium with an octet in the previons principal shell ,Which is now the valence shell . The potassium , because it lost an electron becomes positively charged , while the positive and negative charges attract one another, which then results in the compound KCl .

Q- Write a lewis structure for the compounds .

MgO , NaBr [ Mg=12 , O =16 , Na = 11 , Br= 35 ]

Q-which of the following nonmetals forms an ionic compound with Aluminium with the formula Al2X3 , ( Where x represents the nonmetal ? Al=13

a)Cl (17) b)S(16) c)N(7) d)C(6)

Covalent Lewis structures : Electrons shared .

When nonmetals bond with other nonmetals , a molecular compound results , molecular compounds contain covalent bounds , in which electrons are shared between rather than transferred . In lewis theory . We represent covalent bonding by allowing neigh boring atoms to shave some of their valence electrons in order to attain octets ( or duet for hydrogen ) for example hydrogen and oxygen have the following Lewis structure H∙ ∙O:

In water hydrogen and oxygen share their electrons so that each hydrogen atom gets duet and the oxygen atom get an octet .

The shared electrons – those that appear in the space between the two atoms – count toward the octets (or duets ) of both of the atoms .

Duet

Octet duet

Electrons that are shaped between two atoms are called bonding pair electrons , while those that are only on one atom are called Ion pair electrons .

Ione pair ..

H : O : H

.. Bonding pair

Or non bonding elevtrons

Bonding pair electrons are often represented by dashes to emphasize that they are a chemical bond .

H---- O----H

Lewis theory also explains why the halogens form diatomic molecules . consider the lewis structure of chlorine :Cl:

If two Cl atoms pair together thy can each get an octet .

:Cl:Cl: or :Cl-Cl:

When we examine elemental chlorine , it indeed exists as a diatomic molecule just as Lewis theory predicts .

The same is true for the other halogens .

Similarly , Lewis theory predicts that hydrogen , which has the following lewis structure .H∙

Should exist as Hz . When two hydrogen atoms share their valence electrons , they each get a duet , a stable configuration for hydrogen .

H:H or H-H

Double and triple bounds

In Lewis Theory , two atoms may share more than one electron pair to get octets . For example , oxygen exists as the diatonic molecule , O2 .The Lewis structure of an oxygen atoms is:- :O:

If we pair two oxygen atoms together and then try to write a Lewis structure we do not have enough electrons to give each O atom an octet .

:O :O:

However , we can convert alone pair into an additional bonding pair by moving it into the bonding region .

:O:O:→:O:O: or :O=O: ←

↑ ↑

Octet octet

When two electron pairs are shared between two atoms , the resulting bound is double bound . In general , double bonds are shorter and stronger than single bounds .

Atoms can also share three electron pairs . Consider the Lewis structure af N2 .

Sine each N atom has 5 valence electrons , the Lewis structure for N2 has to electrons .

A first attempt at writing the Lewis structure

Gives :N:N:

Both N atoms do not have enough electrons to satisfy the octet rule.However if we convert two additional lone pairs into bonding pairs , each nitrogen atom can get an octet.

:N:N: → :N:::N: or :N ≡ N:

The resulting bonds called a triple bond . Triple bonds are even shorter and stronger than double bonds . The bond is so strong that it is difficult to break , making N2 a relatively unreactive molecule .

Example : write a lewis structure for CO2  .

Solution : lewis structure for C and O : C , O → :O:C:O: → :O:C:O:

↓

O :: C:: O: or :O= C=O

↓ ↓

Octet Octet:

LEWIS STRUCTURES FOR POLYTOMIC IONS

We write the structure for polyatomic ions by following the same procedure , but we pay special attention to the charge of the ion when calculating the number of electrons for the Lewis structure . Add 1 electron for each negative charge and subtract 1 electron for each positive charge

Write a Lewis structure for the CN- : solution skeletal structure CN

6C 1S2 2S2 2P2← valence e-

7N 1S2 2S2 2P3 ← valence e-

Total number of electron =(valence e- in C ) + ( valence e- in N ) +1

= 4+5+1 =10

We then place two electron between each pair of atoms C:N (2 of 10 electron used ) .

And then distribute the remaining electrons

:C:N: (10 of 10 electrons used ).

Since neither of the atom has octets , we move two Ione pairs into the bonding region to form a triple bond , giving both atoms octets . we also enclose the Lewis structure in brackets and write the charge of the ion in the upper right corner .

[ :C::N]- or [:C=N:]-

Q : The total number of electrons in the Lewis structure of OH- is .

a=6 , b=7 , c=8 , d=9 .

example : write the Lewis structure for the NH4+ ion .

solution skeletal structure

H

H N H H

Valence e- in N=4

Valence e- in H=1

Total number of electrons for Lewis structure = 5+(4x1)-1=8

Place 2 electron between each pair of atoms

H

. .

H : N : H

. .

H

Since the nitrogen atom has an octet and since all of the hydrogen atoms have duets . write the entire Lewis structure . in brackets and write the charge of the ion in the upper right corner .

H + H +

..

H : N : H or H N H

..

H H

EXCEPTIONS TO THE OCTET RULE :

Lewis theory is often correct in its predictions , but there are some exceptions . For example, if we try to write a Lewis structure of NO ,

: N::O: or :N=O:

The nitrogen atom does not have an octet , so this not a great Lewis structure . However , No exists in nature . why ? As with any simple theory . Lewis theory is not sophisticated enough to be correct every time , it is impossible to write good Lewis structure for molecules with add numbers of electrons . Yet some of these molecules exist in nature . Another significant exception to the octet rule in boron

: F : H

: F : B : F : , H : B : H

A third type of exception to the octet rule is also common .

A number of molecules , such as SF6 and PCl5 , have more than 8 electrons around a central atom in their Lewis structure .

:F: :Cl:

:F: :F: :Cl: :Cl:

S P

:F: :F: :Cl: :Cl:

:F:

Q/ Which two species have the same number of Ione electron pairs in their Lewis structures?

a) H2O and H3O+ b)NH3 and H3O+ c) NH3 and CH4 d) NH3 and NH4+

Resonance : Equivalent Lewis structures for the same molecules .

When writing Lewis structures , we may find that , for some molecules , we can write more than one good Lewis structure . For example , consider writing a Lewis structure for SO2 .

Skeletal structure O S O

Total number of electrons for Lewis structure =

(valence e- in S) + 2 ( valence e- in O ) = 6 + 2 ( 6 ) = 18

We next place two electrons between each pair of atoms used O : S : O (4 of 18 electron used )

then distribute the remaining electrons .

:O:S:O: ( 16 of 18 electron used )

And finally to the central atom

:O:S:O: ( 18 of 18 electrons used )

Since the central atom Lacks an octet , we move one Ione pair from an oxygen atom in to the bonding region to form a double bond , giving all of the atom octets .

:O::S:O: or :O=S-O: or :O-S=O:

These two Lewis structures are equally correct . In case such as this – where we can write two or more equivalent ( or nearly equivalent ) lewis structure for the same molecule – we find that the molecule exists in a nature as an average or intermediate between the two Lewis structures .

We account for this in Lewis theory by representing the molecule with both structure called resonance structure .

:O=S-O: :O-S=O:

Double – headed arrow

The true structure of SO2 is intermediate between these two resonance structure .

Q/ write a Lewis structure for the NO3- ion . Include resonance structures .

Electronegativity :- The ability of an element to attract electrons within a covalent bond is called electronegativity .

Oxygen is more electronegativity than hydrogen , which means that , the shared electrons are more likely to found near the oxygen atom than the hydrogen atom

Oδ- Hδ+

The oxygen atom has partial negative charge , symbolized by δ - , the hydrogen atom getting smaller share has partial positive charge , symbolized by δ + . The result of the uneven electron sharing is a dipole moment , a separation of charge within the bond. Covalent bonds that have a dipole moment are called polar covalent bonds . The magnitude of the dipole moment , and therefore the degree of the polarityof the bond depends on the electronegativity difference between the two elements in the bond and the length of the bond . For fixed bond length , the greater the electronegativity difference the greater the dipole moment and the more polar the bond . The electronegativity increases as you go toword the right a cross a period in the periodic table and decreases as you go down a column . If two element with identical electronegativities form a covalent bond , they equally share the electrons , and there is no dipole moment for example Cl-Cl , the covalent bond is nonpolar . ( pure covalent bonding ) .

If there is large electronegativity difference between the two elements in bond , the electron is completely transferred and bonding is ionic . for example Na+Cl- ( metal and non metal ).

If there is intermediate electronegativity difference between the two elements , such as between two different nonmetals the bond is polar covalent . for example . Hδ + Fδ -

Polar bonds and polar molecules .