Chemical Bondings

01. Q. Defient Chemical bonds?

Chemical bonds: A chemical bond is defined as a force that acts between two or more atoms to held then together as a stable molecule.

02 ** Q. Define Valence?

Valence: The number of hydrogen atoms or twice the number of oxygen atoms with which element could combine in a binory compound.

In hydrogen chloride (HCl) one atom of chlorine is combined with one atom of hydrogen and the valance of clorine is 1.

or

Valence is the number of bonds formed by an atom in a molecule.

03 Q. What is Volence electron?

Volonice electron: The electrons in the outer energy level of an atom are the ones that can take part in chemical bonding.

The electronic configuration of Na is 2,8,1 and that of Cl is 2,8,7. Thus sodium has one volonce electron and chlorine 7.

04 ** Q. states electronic theory of volence?

electronic theory of volence: In chemical bond formation, atoms interact by losing, gaining or sharing of electrons so as to acquire a stable noble gas configuration.

Each noble gas except helium, has a volence shell of eight electrons.

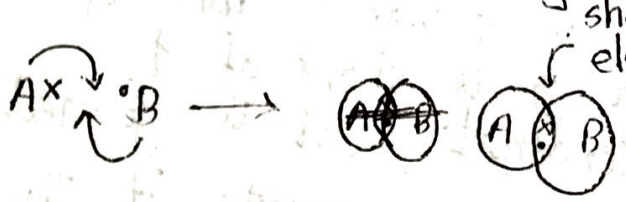
05 ** Q. States the octet theory of valence?

Octet theory of valence:- Atoms interact by electron transfer or electron sharing so as to achieve the stable outer shell of eight electrons.

The tendency for atoms to have eight electrons in the outer shell is also known as the octet rule or the rule of eight.

06 *** Q. What is covalent bond? Exm-2005

covalent bond: The chemical bond between two atoms in which the electrons are shared by both the participating atoms is called covalent bond.



*** Q. Why covalent compounds are soluble in organic solvents?

In general covalent compounds dissolve readily in nonpolar organic solvents. (benzene, ether)

The kinetic energy of the solvent molecules easily overcomes the weak intermolecular forces so Covalent compounds are soluble in organic solvents.

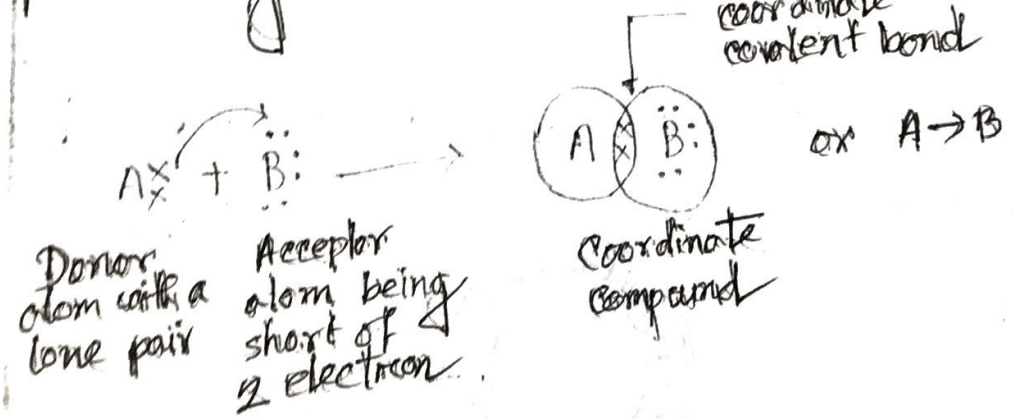
* Q. What is ligand?

Ligand: The molecules or ion that contains the doner atom is called the ligand.

* Q. What is cordinate covalent bond? Explaine it. Exm-2005

Cordinate covalent bonds: a covalent bond in which both electrons of the shared pair come from one of the two atoms or ions.

If an atom A has an unshared pair of electrons (lone paire) and another atom B is short of two electrons than the stable number, a cordinate bond is formed. A donates the lone pair to B which accepts it. Thus both A and B achieve the stable 2 to 8 electrons, the lone pair being held in common.



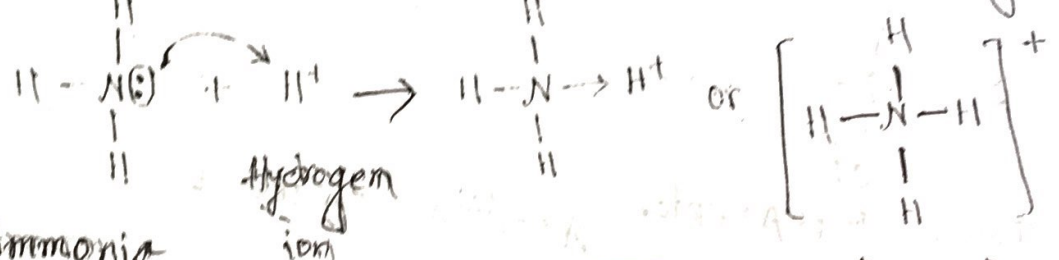
* Explain (i) hydronium ion

10.

Explain the bond formation of (i) Ammonium ion NH_4^+, (ii) Hydronium ion H_3O^+, (iii) Addition compound of NH_3 with BCl_3, (iv) Nitromethane CH_3NO_2, (v) Aluminium chloride Al_2Cl_6, (vi) sulphate ion SO_4^{2-} (vii) Ozone O_3 and (viii) carbon monoxide CO. Help of Lewis concept..

(i) Ammonium ion NH_4^+ :

In ammonia molecule the central N atom is linked to three H atoms and yet N has a unshared pair of electrons. The H^+ ion furnished by an acid has no electron to contribute and can accept a pair of electrons by N atom. Thus NH_3 donates its unshared electrons to H^+ forming ammonium ion.



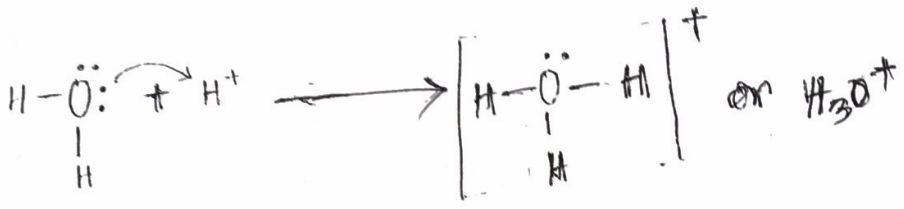
Ammonia molecule — Hydrogen ion — Ammonium ion

(ii) Hydronium ion H_3O^+ :

The oxygen atom in water molecule is attached to two H atoms by two covalent bonds. There are still two unshared pairs of electrons with the O atom. O atom donates of these pairs of electrons to H^+ ion and

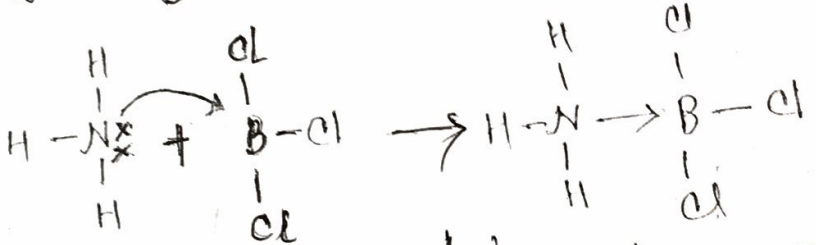
molecule
stable H_2

the hydronium ion is thus formed.



(iii) Addition compound of NH_3 with BCl_3:

The N atom of ammonia molecule (NH_3) has lone pair while B atom in Boron trichloride (BCl_3) is short of two electrons than stable octet. An addition compound is formed as the N atom donates its lone pair to B atom of BCl_3.

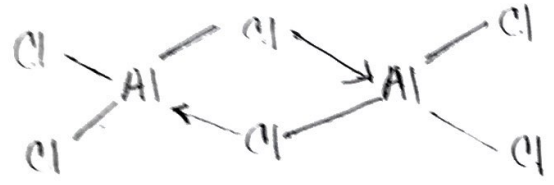


(N is Donor) (B is Acceptor) Addition compound

(v) Aluminium chloride Al_2Cl_6:

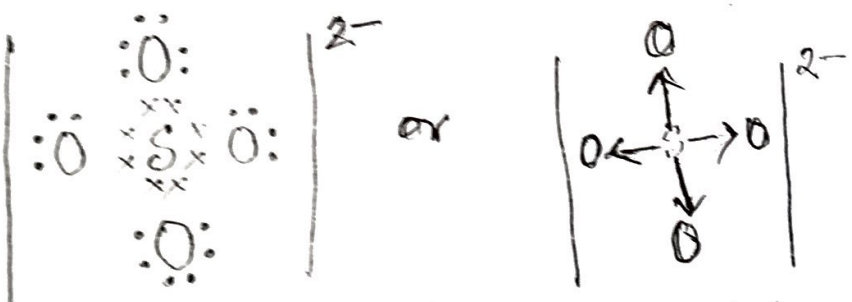
Aluminium atom has three valence electrons which it shares with three Cl atoms forming three covalent bonds. Thus the Al atom acquires six electrons in its outer shell. Now Cl atom has three lone pairs, one of which is donated to the Al atom of another

molecule $AlCl_3$. Thus both Al atoms achieve octet and stable Al_2Cl_6 results.



(vi) Sulphate ion, SO_4^{2-}:

Sulphate has six valence electrons (2, 8, 6) and achieves the octet by gaining two electrons from metal atoms (say two Na atoms). The four pairs of electrons around the S atom are then donated to four oxygen atoms each of which has six electrons. Thus the Lewis structure for SO_4^{2-} ion may be written as

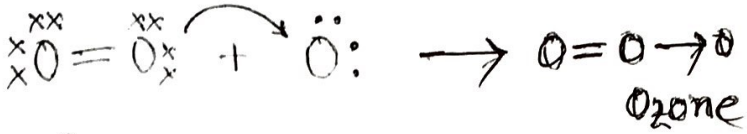


S gains two electrons from metal atoms and completes octet..

sulphate ion

(vii) Ozone O_3:

Oxygen molecule is made of two oxygen atoms joined by two covalent bonds. Each O atom in O_2 has two unshared pairs of electrons. When one pair of these is donated to a third O atom which has only six electrons a coordinate bond is formed. Thus the lewis structure of ozone may be represented as:



Oxygen
(2 Atom of O)

*** Q. write short note on Ionic character of covalent bonds. -2001,

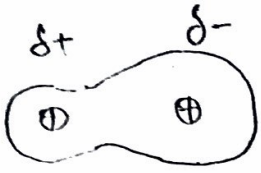
or

*** Q. What is the ionic character of covalent bonds

The covalent bond between the same atoms or atoms of same electronagativity is called homopolar or nonpolar covalent bond. In this bond the electron pair is equally shared by both the linked atoms.

The covalent between two atoms which differ in electronegativity is called the polar covalent bond. In this bond the electron pair is unequally shared

by the bonded atoms and a fractional positive and negative charges are created on them. i.e a dipole is produced.



All the covalent bonds in the hetroatomic molecules are polar. e.g H-O in H_2O, N-H in NH_3 etc.

The polar covalent bond is partially ionic and partially covalent. This is called the ionic character of covalent bond.

The degree of this ionic character in covalent bond depend on the difference in electronegativities of the bonded atoms.

Q. Establish the increasing order of ionic bonding amongst KI, NaI, LiI, RbI, CsI and explain the trend. Exm — 2002.

Ans: Smaller is the size of the cation, highe is its polarizing power to polarize a given nearb anion. and we know that the greater polarity amoun the compounds show less ionic bond.

According to above concept we can arrange the give compound accordin to their increasing order of ionic bond.

Therefore

12 *** Q. Establish the increasing order of ionic bonding amongst KI, NaI, LiI, RbI, CsI and explain the trend Exm — 2002.

Ans: On moving down a group the size of the cations increases and hance the polarising power of the cations goes on decreasing. But we know that decreasing the polarizing power the compound shows high ionic bond.

According to the above concept we can arrange the given compound according to their increasing order of ionic bond.

There fore

~~CsI > RbI > KI > NaI > LiI~~.

$LiI < NaI < KI < RbI < CsI$.

13 ** Q. Arrang the following compound in ~~their~~ order in their increasing covalency. $AlCl_3$, NaCl, $SiCl_4$, $MgCl_2$. explain the term d— Extra 2003.

Ans: Higher the positive chaarge on the cation, greater its polarising power to polarise a given nearby anion. In $AlCl_3$, NaCl, $SiCl_4$ and $MgCl_2$ molecules the polarising power of Na^+, Mg^{2+}, Al^{3+} and Si^{4+} cations to polarise a anion increase with the increase of positive charge on them as shown below.

$Na^+ < Mg^+ < Al^{3+} < Si^{4+}$.

According to the above concept we can arrange the given compound according to their increasing order of covalency

$NaCl < MgCl_2 < AlCl_3 < SiCl_4$.

14 *** Q. Establish the increasing order of ionic bonding amongst $CaCl_2$, KCl, $TiCl_4$ and $SeCl_3$ and explain the trend. Exm – 2003.

Ans:- Higher the positive charge on the cation, grater its polarising power to polarise a given nearby anion. But we know that the greater ~~pot~~ polarity amoung the compounds show leser ionic bond.

According to the above concept we can arrange the given compound according to their increasing order of ionic bond. Therefore

$TiCl_4 < SeCl_3 < CaCl_2 < KCl$ → ionic bonding

or $KCl < CaCl_2 < SeCl_3 < TiCl_4$ → covalency

15 ** Q. Establish the increasing order of induced covalency amongst $CaCl_2$, KCl, $TiCl_4$ and se $SeCl_3$ and explain the trend. — 2002. Exm

Ans: Higher the positive charge ol on the catain greater its polarising power to plarise a given nearby anion. In KCl, $CaCl_2$, $TiCl_4$ and $SeCl_3$ molecules the polarising power of Li^+ K^+, Ca^{2+}, Se^{3+} and Ti^{4+} cations.

to polarise Cl^- anion increases with the increase of positive charge on them as shown below.

$$K^+ < Ca^{2+} < Sc^{3+} < Ti^{4+}.$$

According to above concept we can arrange the given compound according to their increasing order of covalency.

$$KCl < CaCl_2 < ScCl_3 < TiCl_4.$$

16 ** Q. Arrange the following compound in order of their increasing covalency. $AlCl_3$, NaCl, $SiCl_4$, $MgCl_2$ - 2002

Ans:- The increasing order of covalency is

$$NaCl < MgCl_2 < AlCl_3 < SiCl_4.$$

*** Q. The melting point of $BeCl_2$, $MgCl_2$, $CaCl_2$ are 405°c, 712°c and 772°c respectively - Explain why? Exm - 2005.

Ans:- With the increase of polarisation, the degree of covalent character in an ionic compound also increases and this increased covalent character decreases the melting point of the compound.

The decrease in covalent character in $BeCl_2$ to $CaCl_2$, so in order increase the melting points of these chlorides in the same direction. In this reason the melting point of $BeCl_2$, $MgCl_2$, $CaCl_2$ are 405°c, 712°c and 772°c respectively.

* 100°c Q. The decomposition temperature of $BeCO_3$ is 100°c while that of $BaCO_3$ is 1360°c. Explain this difference - 2002

Ans:: $BeCO_3 \rightarrow 100°c$

$BaCO_3 \rightarrow 1360°c$

Ans: with the increase of polarisation, the degree of covalent character in an ionic compound also increases and this increase covalent character

decreases the decomposition temperature of the compound.

The decrease the in covalent charecter from $BeCl_2$ $BeCO_3$ to $BaCO_3$. so increase the ~~do~~ decomposition temperature of these $-CO_3$ corbonate in the same direction. so the decompasition temperature of $BeCO_3$ and $BaCO_3$ is difference.

19 ** Q. Arrange the following compound in order of their solubility in water and give explanation. AlF_3, $AlBr_3$, $AlCl_3$ and AlI_3. Exm-2005.

Ans: With the increase of polarisation, the degree of covalent charecter in an ionic molecule increases. with the increase of covalent character, the solubility in polar solvent like H_2O decreases. with the

The covalent charecter of the halides of Al increases from AlF_3 to AlI_3

$AlF_3 < AlCl_3 < AlBr_3 < AlI_3$

- covalent charecter increasing →

with the increase of covalent character from AlF_3 to AlI_3 solubility of these halides in polar solvent like H_2O water decreases in the same direction as shown below:

$$AlF_3 > AlCl_3 > AlBr_3 > AlI_3.$$

20*** Q. Explain why CuCl is covalent compound but NaCl is ionic compound.?

Ans: $Cu^+ - Cl^-$ bond in CuCl is more covalent than $Na^+ - Cl$ bond in NaCl, since Cu^+ has $3s^2p^6d^{10}$ configuration while Na^+ has $2s^2p^6$ configuration. Due to 18-electron valence-shell configuration Cu^{2+} ion has greater polarising power to polarise Cl^- ion than Na^+ ion having 8-electron valence-shell configuration. So CuCl is a covalent compound and NaCl is a ionic compound.

21

** Q. Explain why Ionic compounds are usually soluble in polar solvents but not in non-polar solvent.
Exm-2000.

Ans: With the increase of polarisation, the degree of covalent character in an ionic molecule increases. This increase in covalent character is accompained by an increases of the solubility of the compound in non-polar solvent but is its solubility in polar solvent decreases with the increase in covalen character.

But we know that the increasing the polarising power it deacreases the ionic character. Deacreases ionic character its increase the solibility in polar solvent.

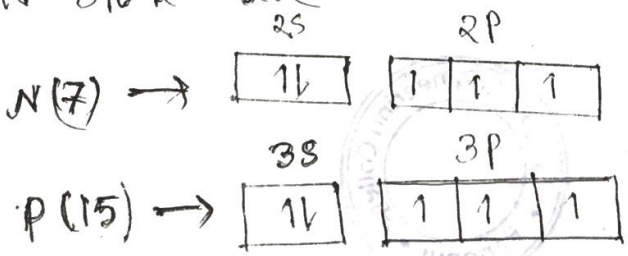
According to above concept we say that Ionic compound are usually soluble in polar solvents but not in a non-polar solvent.

22 *** Q. $SiCl_4$ is easily hydrolysed by H_2O but CCl_4 is not → Explain why? Exm 2001, 2004, 2006.

Ans: we know C atom is a member of 2nd period of the periodic table. It has no d-orbital in its valence shell and can not accept lone pair and don and can not by doneted the oxygen atom of H_2O molecule ∧ to form unstable intermidiate compound. Thus the tetrahalide of carbon are not hydrolised. on the other hand Si has d-orbitals which can accept the lone pair and its tetrahalide get radially hydrolised. For this reson $SiCl_4$ is easily hydrolysed by H_2O but CCl_4 is not hydrolysed.

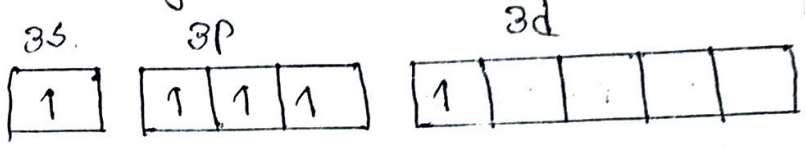
2nd *** Q. PCl_5 is stable while NCl_5 can not be prepared. Explain? Exm — 2001, 2004.

Ans: The electronic configuration of N and P in Ground state are



we see from the electronic configuration that

both the electronic have three unpaird electron in their outermost p orbital and show thay equal valency 3 and can form halide NCl_3, PCl_3, But in excited state of p the electronic configuration as.



From the configuration it can proced that p shows 3 and 5 covalence and can form PCl_5 but N can not shows because it has no 3d orbital.

---

24 ** Q. OF_6 does not exist while SF_6 exists. ~~Exm-2001,2004~~ Explain. ~~Exm-2001~~,2004.

Ans: The electronic configuration of s and o are

$O(8) \rightarrow 1s^2 2s^2 2p^4$

$S(16) \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^4 3d^0$

From the electronic configuration of o and s we can say that s shows its maximum covalency of six by using its d-orbitals and can form hexafluride.

On the other hand, oxygen atom which shows only two unpaired electron on its p-orbital and can not form hexafluride.

Therefore OF_6 does not exist while SF_6 exists.

3: Define coordinate covalent bond with appropriate Example 2005.

*** Q. what is octet rule? Explain it with suitable example. ◦ Exm:- 2001, 2003, 2004.

Octet rule: The tendency of the atoms to have eight electrons in their outer most shell is known as octet rule or rule of eight.

Explain: (i) Atom with 8 electrons of chemical in the outer most shell are chemically stable and hance are incapable of chemical combination. As for examples ~~He~~ Ne

(ii) An atom having less than 8 electrons it its outer most shell is chemically active and hance has a tendency to combine with other atoms, to form a electronic configuration of a inart gas. ◦ E.g. Cl_2 ato

26

*** Q: Discus the properties of ionic compounds.- 2000

Properties of the ionic compounds:

(i) Physical state: Ionic compounds consist of three dimentional solid aggregates of cations and anions which are arrange in a well defined geometrical patten. Thus ionic compound are crystaline solids at room temperature.

(ii) Electrical conductivity: Ionic compounds do not conduct electricity when they are in the solid state. The ionic compounds are good conductors of when they are in water solution or in the fused (molten) state.

(iii) They are quit hard, have low volatility and high melting and boiling point.

(iv) They are soluble in the polar solvent like water and unsoluble in non-polar solvent.

(vi) Stability: Ionic compounds crystals are very stable compounds and for maximum stability of these crystals the oppositively charged ions are close to one another and the similarly charged ions are so as away from one another as possible.

Q. Explain why the ionic compound are not Electrical conductivity in the solide state?

Ans: In the solid state the cations and anions on account of electric force of attraction existing between them, remain tightly held together with each other in the ionic compounds and hence occupy their fixed positions in the crystal lattice the ions, therefore, cannot move freely to any large extent when an electric current is passed through the ionic solids. Hence the ionic compound are not Electrical conductivity in the solid state.

23 *** Q. What are the factors favouring the formation of a covalent bond between two atoms A and B against on ionic bond? Exm - 2001, 2003, 2004.

Ans: In the different of electronegitivity between the element's of a ionic bond being lower the density of electron could go the middle of two nuclei and get some covalent property. This appearence is called known as polarization.

There is a rule about polarization which known a Fajans rule which explained bellow,

(i) The polarity of compound as well as the intens of covalent property increase with the decreasing of volume cations.

e.g. the covalent character of bond in $BeCl_2$ $MgCl_2$ $CaCl_2$ & $BaCl_2$, $SrCl_2$ molecules decrease in the following order.

$$Be^{++}-Cl^- > Mg^{++}-Cl^- > Ca^{++}-Cl^- > Sr^{++}-Cl^- > Ba^{++}-Cl^-$$

(ii) The covelant bond increase with the increasing order of the size of the anion.

e.g the covalent character of bond in CaF_2, $CaCl_2$

$CaBr_2$, CaI_2 respectively increase in the following order

$Ca^{++}-F^- < Ca^{++}-Cl^- < Ca^{++}-Br^- < Ca^{++}-I^-$

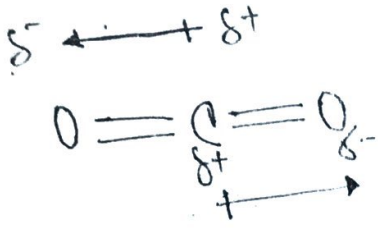
(iii) The intensity of covalent property in the ionic bond developed with the is electron valanceshell configuration.

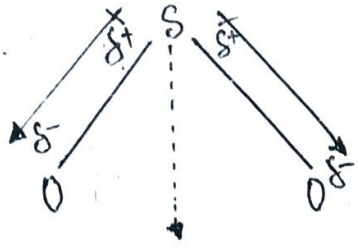
(iv) Increase in covalent charecter in accompained by as increase of the solubility of the compound in non polar solents like alcohol but its solubility in polar solvent like H_2O decrease with the increase in covalent charecter.

(v) with the increase of polarization the degree of covalent character in an ionic compound also increase and the increase covalent charecter decrease the melting point of the compound.

*** Q. Explain why SO_2 has a dipole moment but while CO_2 does not? Exm 2000, 2007

Ans: The CO_2 molecule is non-polar, although the C=O bond is polar. The polarity of C=O bond on one side is canc by C=O bond on the other side because the CO_2 molecule is linear. Consequently dipole moment of CO_2 is zero.





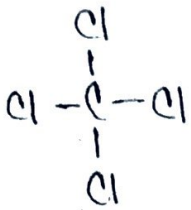
But the SO_2 molecule is not linear. It has bent structure of shown in the figure. In this molecule there are two dipolar bonds d. and the resultant of the diple moment of these individual dipolar bonds give the dipole moment of the molecule.

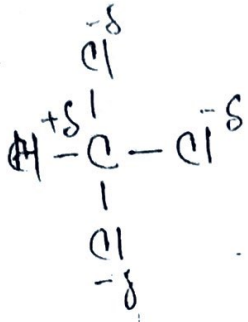
30

*** Q. Explain why $CHCl_3$ is polar but CCl_4 is non-polar.? Exm-2003.

Ans: The polarity of a compound depends on the difference in electronegativities of the constituent elements of that compound. The greater difference in electronegativities the greater is the dipole moment. Consquently the degree of polarity of the polar-moment covalent bond between the linked atom is increased.

In CCl_4 carbon is attached with four chlorine atoms ie with same type of atom. Therefore, the electronegativities of the linked atom will be same. Consquently the CCl_4 is non-polar.





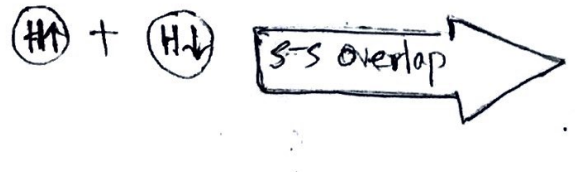
When as the $CHCl_3$ molecule contain one hydrogen atom and three chlorine atoms. The electronegativity of chlorine is higher than the hydrogen. So the three chlorine atom attract the shared electron pairs toward itself. Consequently they become $-\delta$ charged and the hydrogen atom become $+\delta$ charged. In this way the $CHCl_3$ become a polar molecule.

*** Q. what are σ and π bonds? How are they formed? Illustrate with suitable examples. Exm- 2006.

σ bond: A covalent bond which is formed between two atoms by the overlap of their half-filled atomic orbitals along the line joining the nuclei of both the atoms is called a sigma (σ) bond.

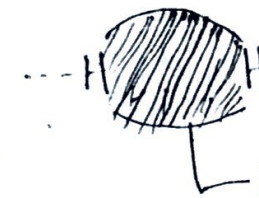
σ bond is produced by the head to head overlap of the half-filled atomic orbitals of the two atoms.

e.g. the formation of a H_2 molecule:



s-s overlap

formation of H-H σ bond



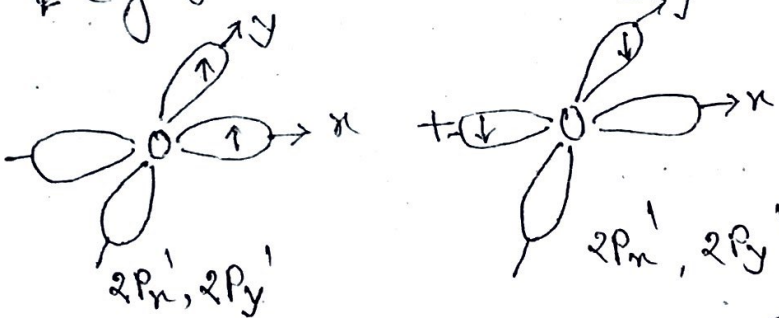
or H–H σ bond

H — H

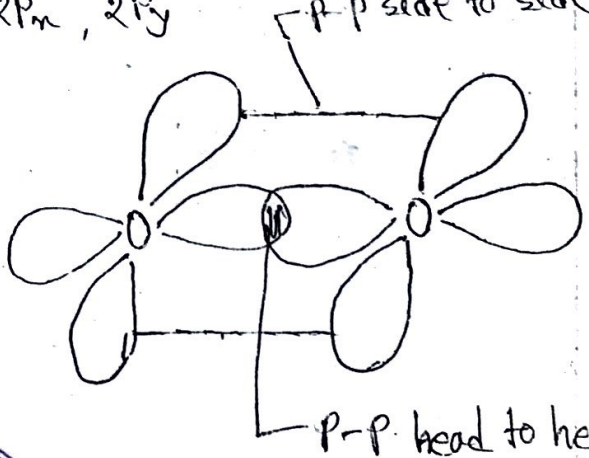
π-bond: A covalent bond which is formed between two atoms by the over lap of their singly filled p-orbitals along a line perpendicular to their nuchear axis is called a π-bond.

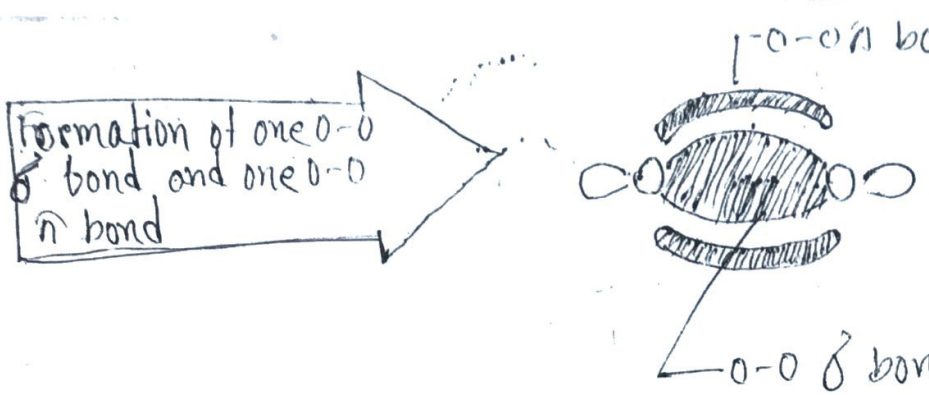
π-bond is produced by the side-to-side overlap of half-filled p-orbitals of the two atoms.

* e.g formation of O_2 molecule:



P-P head to head overlap and P-P side to side overlap





Q. Different between σ and π bonds:- Exm-2002.

Difference between sigma and pi bond:

sigma bond	pi-bond
(i) It is formed by end to end overlapping of half filled atomic orbitals.	(ii) It is formed by the sidewise overlaping of half filled p- orbitals or
(ii) Overlapping takes place along internuclear axis.	(ii) Overlapping takes place perpendicular to internuclear axis.
(iii) The extent of overlapping is large and bond formation is stronger	(iii) The extent of overlaping is small and bond formation is weaker.
(iv) There is free rotation about σ bond and no geometrical isomers are possible.	(iv) There is no free rotation about π bond and geometrical isomers are possible.
(v) The bond can be present alone	(v) The bond is always formed in addition to sigma bond.
(vi) s and p orbital can participate in the formation of σ bond.	(vi) Only p- orbital participate in the formation of π bond.

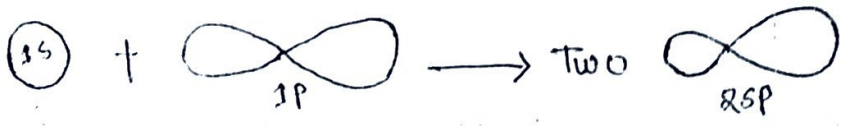
33 ** Q. Explain why a σ bond is stronger than a π bond? Exm- 2004.

Ans: The probability of finding the electrons between the two nuclei (i.e on the ~~both~~ bond axis) is maximum, since they are attracted by both the nuclei. It is for this reason that σ bond is a very strong bond. On the other hand the probability of finding the electrons between the nucle (ie on the bond axis) is poor and hence π-bond is a poor bond. so σ bond is stronger than a π- bond.

34 ** Q. what do you understand by hybridization of bond orbital? Exm:- 2001, 2000.

Hybridization of bond orbital: The process of mixing pure atomic orbitals on an atom of nearly equal energy to produce a set of entirely new orbitals which are equal in number to the mixing orbitals have the same energy and in identical shapes and are symmetrically disposed in space round the atom is known as hybridisation and the new orbitals produced are called hybid orbitals.

Examples: (i) sp hybridization:

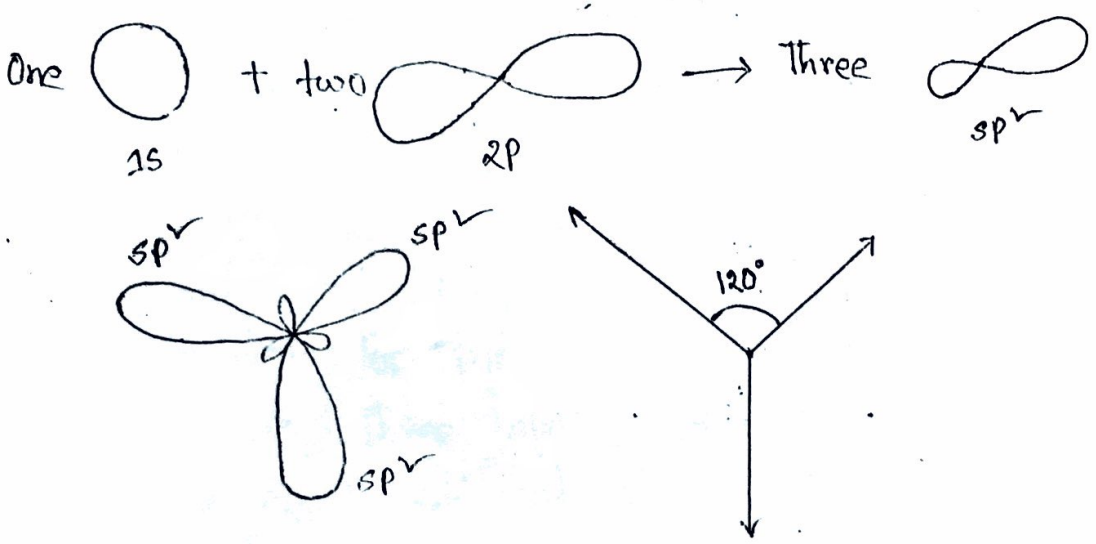


(ii) sp^2 hybridization:

*** Q. Discus sp, sp^2, sp^3. th types of hybridization giving one example in each case. Exm:- 2001, 2004.

<u>sp hybridization</u>:- one s and one p orbital are formed sp hybridization. sp orbital has 50% s-character and 50% of p- character.. The onl angle of this hybridization is 180° and is also called linear hybrid orbitals. For examples are $BeCl_2$ and BeF_2 etc.

sp^2 hybridization :- 1s and 2p orbital mix up and to form three new orbitals is called sp^2 hybridization. sp^2 hybridization orbital has 33% s character and 67% p character. The angle of this hybridization is 120°. The sp^2 hybridization is called Trigonal hybrids. or hybridization. For example: BF_3, NO_3^- etc.

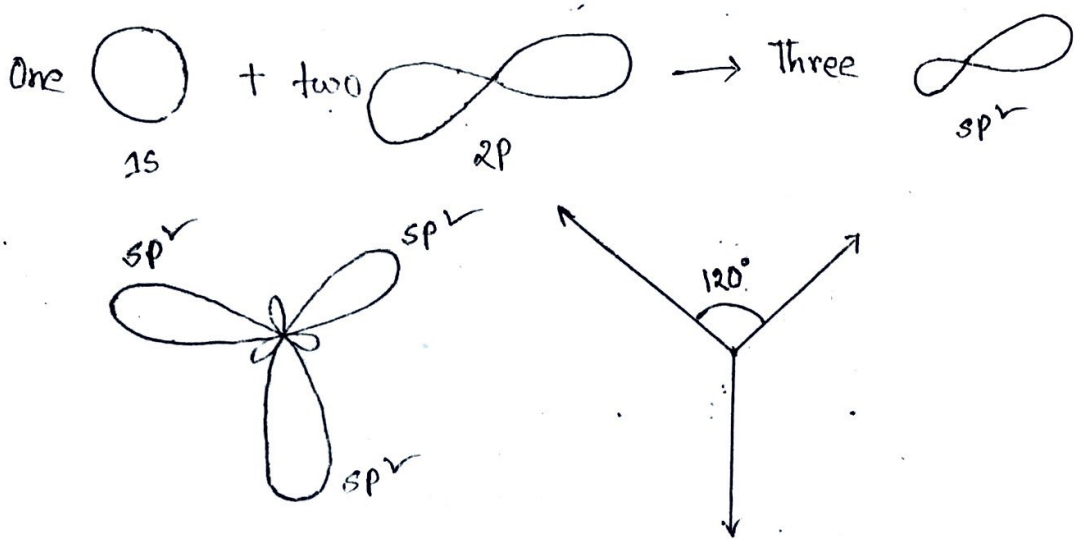


sp^3 hybridization :- 1s and 3p orbital mix up and to form four new orbitals is called sp^3 hybridization. sp^3 hybrid orbital has 25% s character and 75% p character. The angle of this hybridization is 109.5° The sp^3 hybridization is called Tetrahedral hybridization. As for example CH_4, ClO^-, SO_4^{2-} etc

Figer

P.T.O

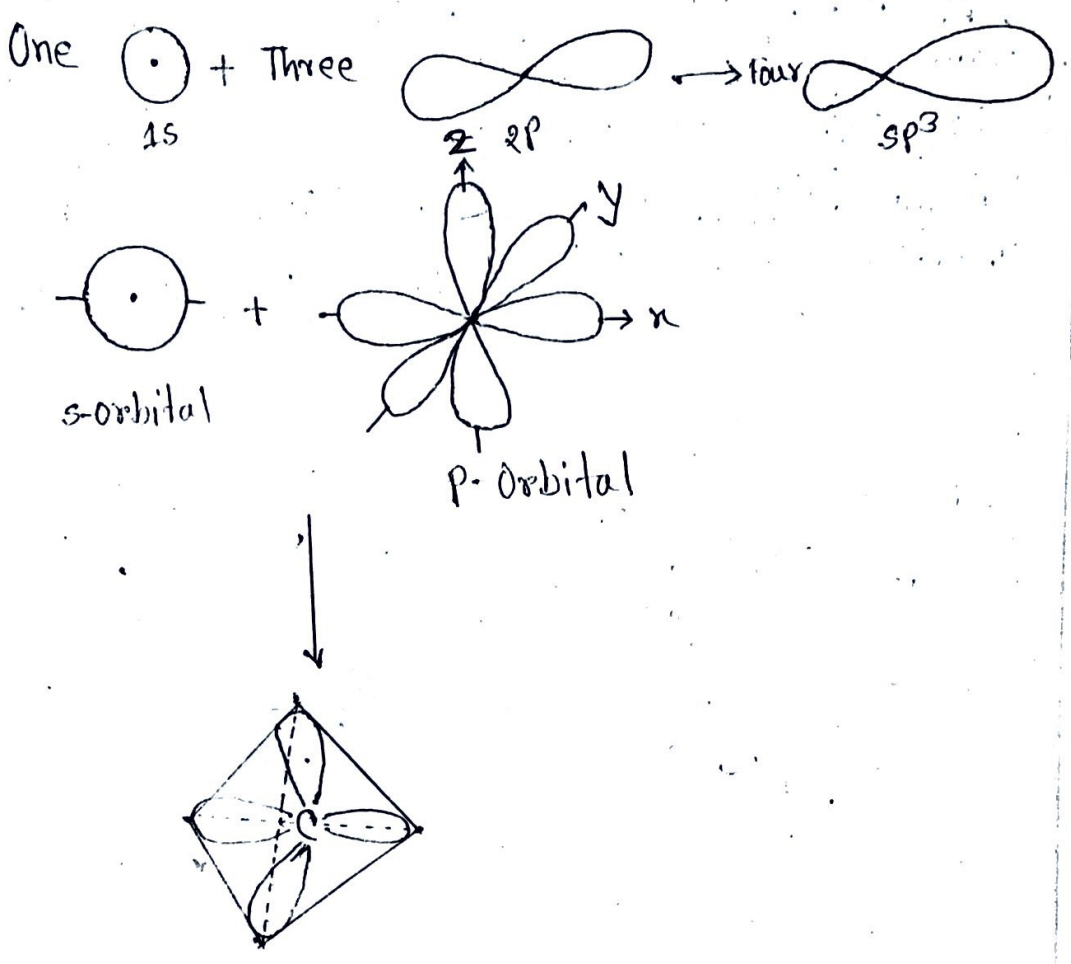
sp^2 hybridization :- 1s and 2p orbital mix up and to form three new orbitals is called sp^2 hybridization. sp^2 hybridization orbital has 33% s character and 67% p character. The angle of this hybridization is 120°. The sp^2 hybridization is called Trigonal hybrids. or hybridization. For example: BF_3, NO_3^- etc.



sp^3 hybridization :- 1s and 3p orbital mix up and to form four new orbitals is called sp^3 hybridization. sp^3 hybrid orbital has 25% s character and 75% p character. The angle of this hybridization is 109.5° The sp^3 hybridization is called Tetrahedral hybridization. As for example CH_4, ClO^-, SO_4^{2-} etc

Figer

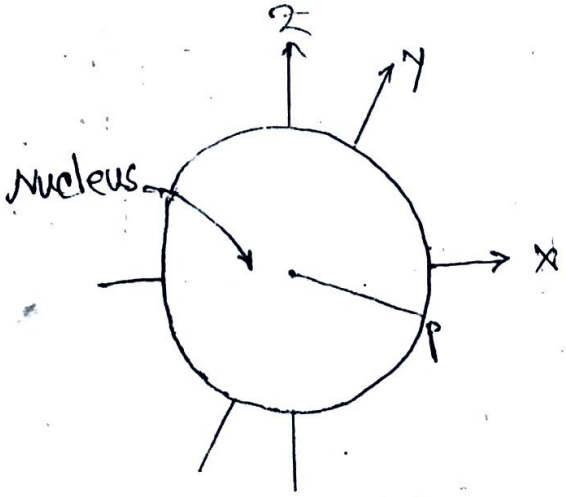
P.T.O



Four sp^3 hybrid orbital of carbon.

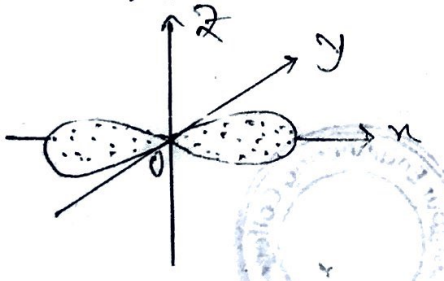
mb ** Q. Discus the physical significance of s, p and d orbitals. Exm-2002.

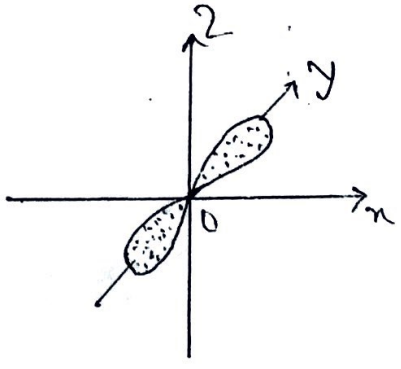
s-orbital: s orbital has a symmetrically sh spherical shape and usually represented by a circle. For s-subshell $l=0, m=0$. This skill It can be arranged in space only one way along x, y, and z axis. s-sub shell has on space orientation. It has no orbital and is present in all the energy levels.

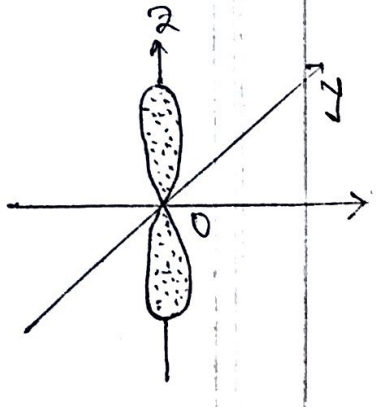


s-orbitals

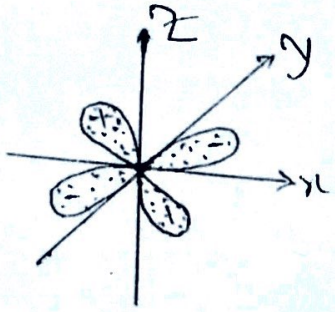
P-orbitals: For ~~this~~ sub-shell $l=1$ when $l=1$. $m = 0, \pm 1$. P-subshell has three space orientation and can be arranged in space in three different way along x, y and z axes, which is P_x, P_y, and P_z. Therefore p-sub shell is sub-divided in three orbitals which on the Basis of the orientation of their lopes of maximum electron density with respect to x, y and z axes are designated as $P_x (m=0)$, $P_y (m=+1)$ and $P_z (m=-1)$.



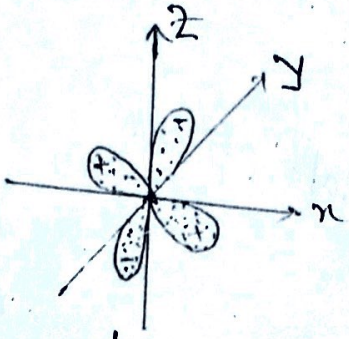




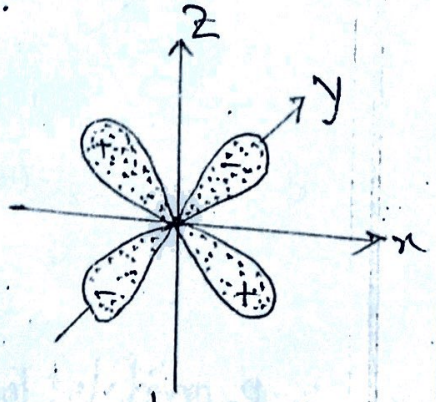
d-orbitals: For this sub-shell when $l=2$ then $l=2$ $m=0, \pm 1, \pm 2$, d-subshell starting form from 3d 3rd energy level with is composed of five orbitals which are represented as d_{xy}, d_{yz}, d_{zx}, d_{z^2}, $d_{x^2-y^2}$.



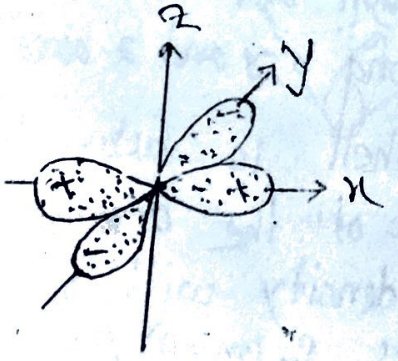
d_{xy}



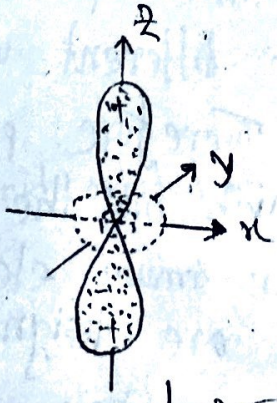
d_{yz}



d_{zx}



$d_{x^2-y^2}$



d_{z^2}

32 ** Q. Discuss the bond formation in the following molecules with the help of hybridization concept (i) CH_4 (ii) NH_3 (iii) BeF_2. Exm: 2000.

or, Discuss the shaps of the following molecul with the help of hybridization concept: BF_3, CO_3^{2-} and SO_2. Exm: 2001

or, Indicate the nature of hybridisation and deduce the geometry of the following molecules ClF_3, XeF_4, IF_5 and $SnCl_2$. Exm: 2003

(i) Formation of CH_4:

Electronic configuration of C:

in Ground state $C(6) \rightarrow 1s^2 2s^2 2p_x^1 2p_y^1 2p_z^0$

In Excited state $C(6) \rightarrow 1s^2 2s^1 2p_x^1 2p_y^1 2p_z^1$.

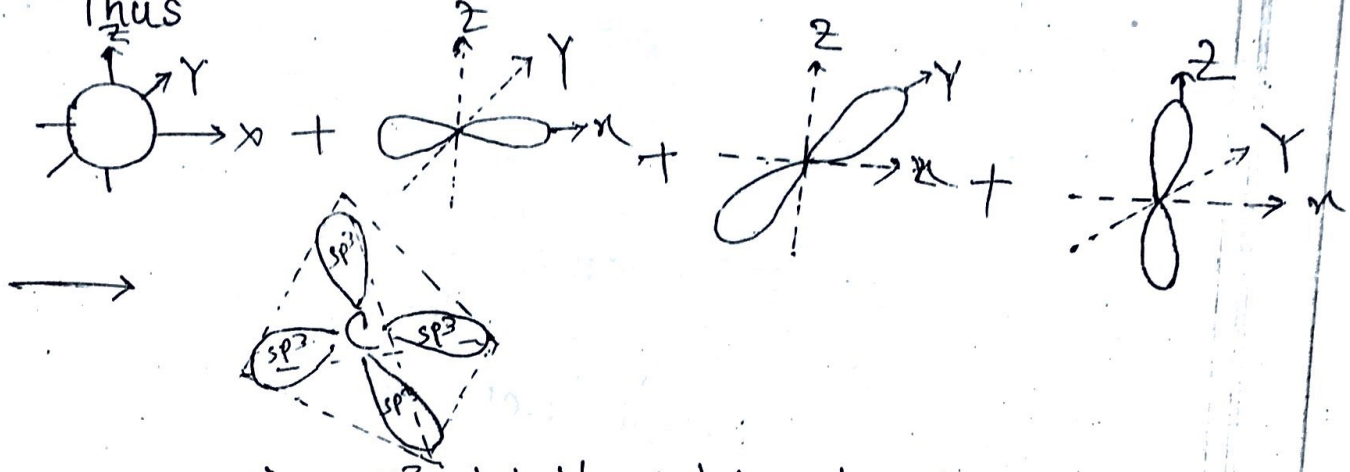
In the formation of CH_4 it has four C-H bond are namely (i) 2(C) – 1s(H) (ii) $2p_x$(C) – 1s(H) (iii) $2p_y$(C)–1s(H) (iv) $2p_z$(C) – 1s(H).

At first one s and three p orbital in C formed sp^3 hybrid orbital

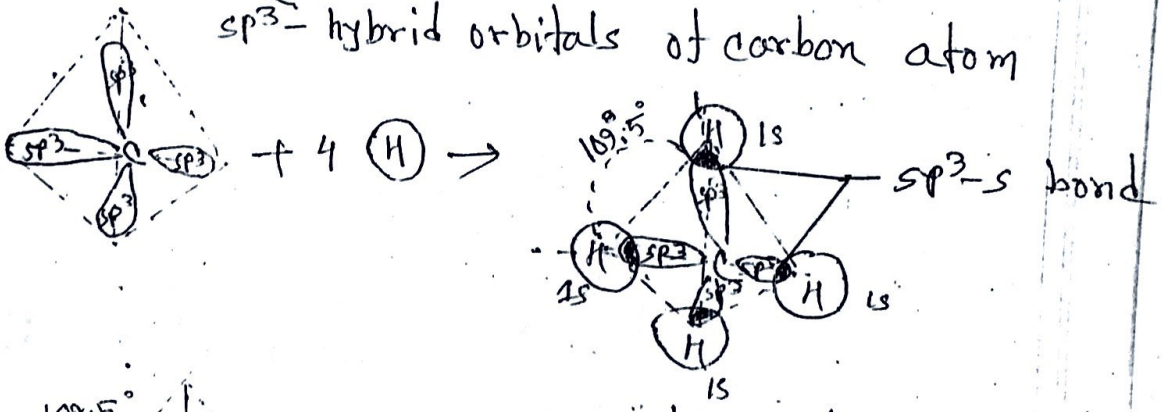
and then sp^3 in carbon and joined with H molecule ~~at~~ and to form sp^3-s hybridization in CH_4 molecule.

~~Thus~~

Thus

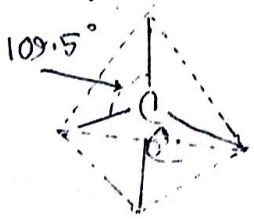


sp^3- hybrid orbitals of carbon atom



Formation of CH_4 molecule

or



or

the bond angle of CH_4 is 109.5°. Hence is tetrahedral shape.

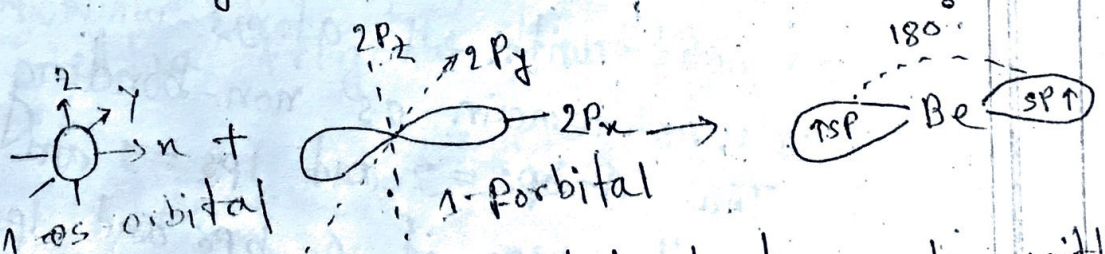
(ii) Formation of BeF_2:

The electronic configuration Be.

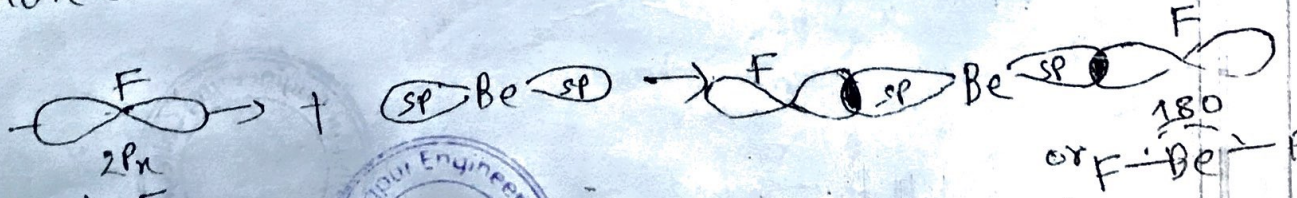
Ground state Be (4) → $1s^2 2s^2 2p_x^0 2p_y^0 2p_z^0$

Excited state Be (4) → $1s^2 2s^1 2p_x^1 2p_y^0 2p_z^0$

The Lewis structure of this molecule F–Be–F shows that the central atom namly Be atom ($2s^2$) uses both its velence-shell electrons in forming 2 bonds with two F atoms. Thus σ-bps = 2 and lps = 0 and hence σ-bps + lps = 2. Now since the sum of σ-bps an lps = 2. Be atom in this molecule is supposed to sp hybridization.



These orbitals make a head to head overlap with singly-filled 2Px orbital on each of the two F atom ($F \rightarrow 2s^2 2p_x^1 2p_y^2 2p_z^2$) and to form $BeCl_2$ molecule.



the angle is 180°. so it gives linear shape.

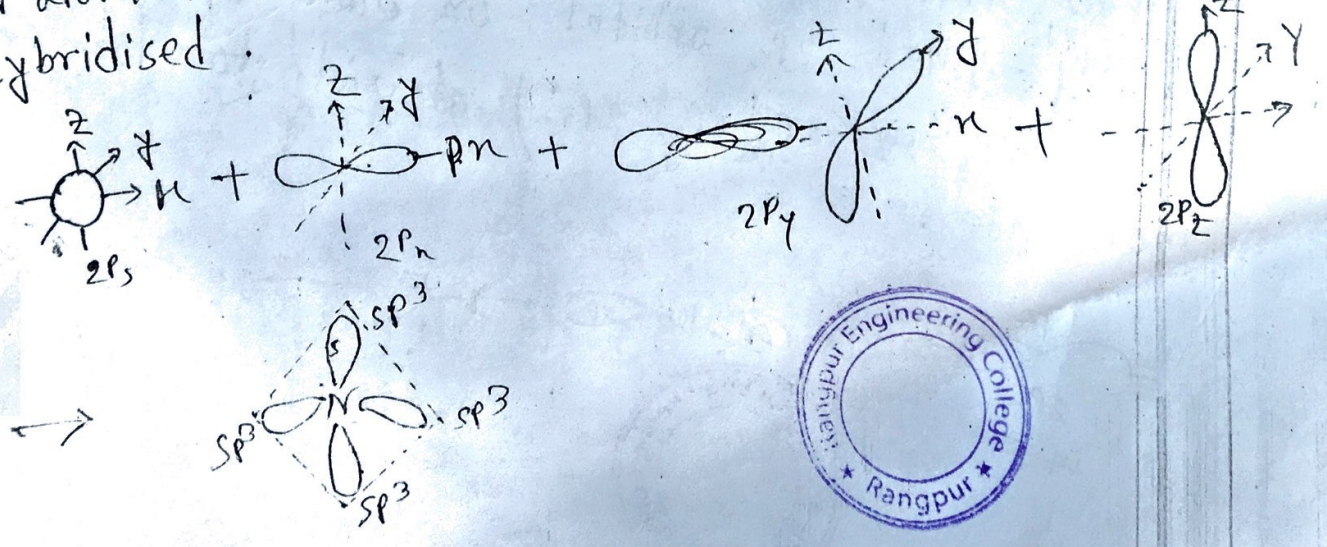
(iii) Formation of NH_3 molecule:

The electronic configuration of N is:

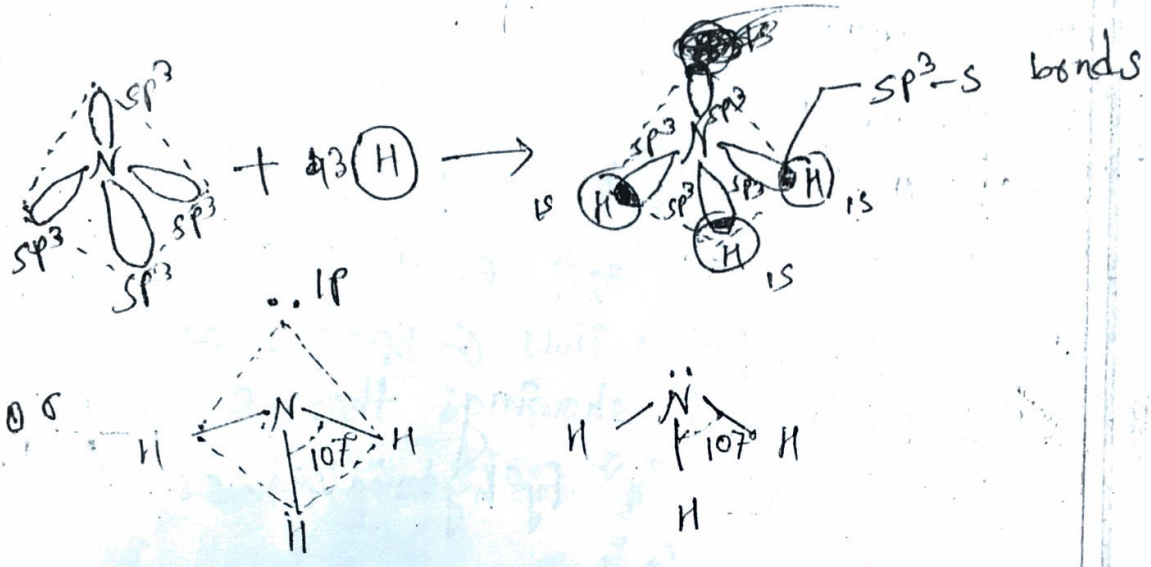
Ground state: $N(7) \rightarrow 1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$

The lewis structure of this molecule $H-\underset{\cdot\cdot}{\overset{H}{\overset{|}{N}}}-H$ shows that the central atom uses only three electrons. Out of its five valance shell electrons ($N \rightarrow 2s^2p^3$) three are used up in forming 3σ bond with 3H atoms while the remaining two electrons remain as non-bonding electron on N-atom. Thus σ-bps = 3 and lps = 1 and σ-bps + lps = 4

Now since the sum of σ-bps and lps = 4. Hence N atom in NH_3 molecule is supposed to be sp^3 hybridised.

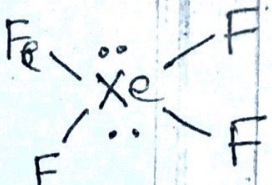


sp^3 orbital of N joined with three H. to forme NH_3 as sp^3–s hybridyzation



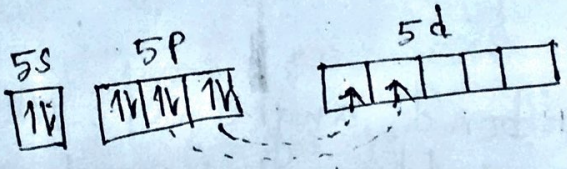
The bond angle of NH_3 is 107°. Hence the NH_3 is ~~tettra~~ trigonal pyramidal shape.

3. Formation of XeF_4 molecule:

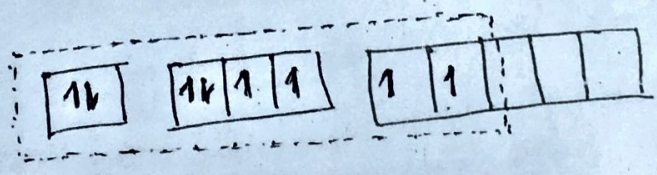


Lewis structure of this molecule, shows that the central atom namely Xe atom uses only four of its eight valence-shell electron ($Xe \rightarrow 5s^2p^6$) in forming four Xe–F σ-bonds and the reminig two electrons pairs remain as lps on Xe atom. Thus σ-bps = 4 and lps = 2 Hence ~~σ~~ σbps + lps = 6 showing that xe atom in XeF_4 molecule is ~~sp^3d^2~~ sp^3d^2 hybridised. ~~as shown in~~

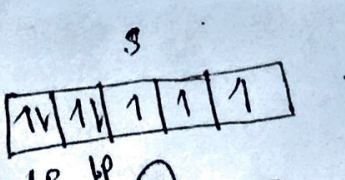
Xe atom in its ground state ($5s^2p^6$)



Xe atom in its doubly excited state



Xe atom in sp^3d^2 hybridised state



or

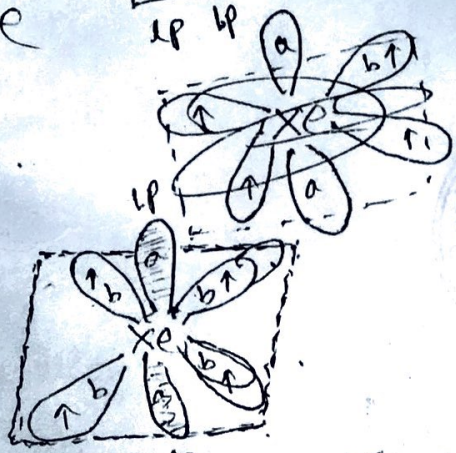
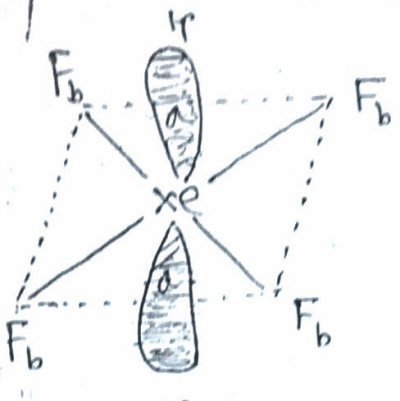


Fig:- sp^3d^2 hybridization by Xe atom.



square plane structure of XeF_4 molecule.

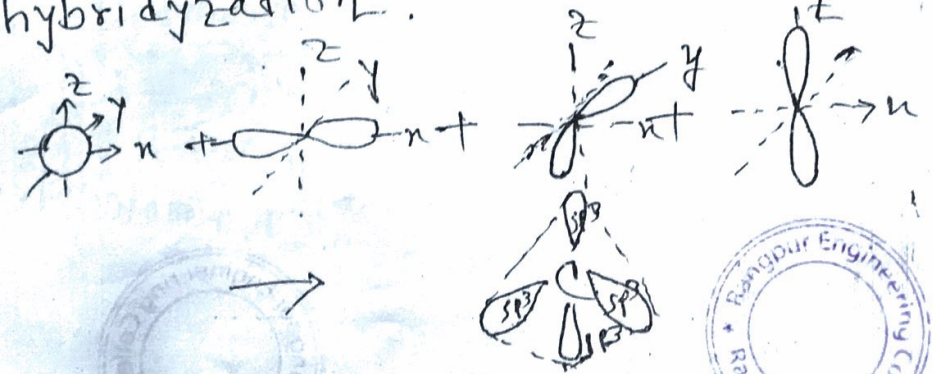
Formation of CO_3^{2-} :

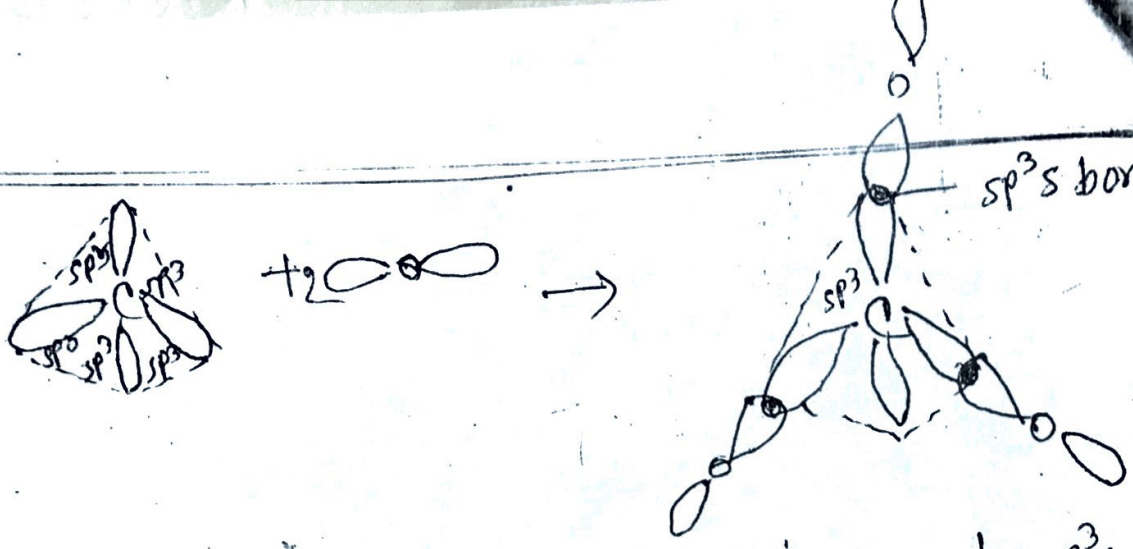
Electronic configuration of C:

Ground state: $C(6) \rightarrow 1s^2 2s^2 2p_x^1 2p_y^1 2p_z^0$

Excited state: $C(6) \rightarrow 1s^2 2s^1 2p_x^1 2p_y^1 2p_z^1$.

The lewis structure of this molecule $-O-\overset{\ominus}{\underset{\ominus}{C}}=O$ shows that the central atom uses its valence shell. bps = 4 and lps = 0. Now since σ - bps + lps = 4. C atom in this molecule is supposed to be sp^3 hybridyzation.





Formation of sp^3s orbital in CO_3^{2-}.

অন্যান্য এর R.D. Madan এর Chemical Bonding (orbital concept) থেকে দেখে নিতে হবে।

মূল Q. of CH_4, NH_3 and H_2O molecules have different bond angle - explyn why? 2002

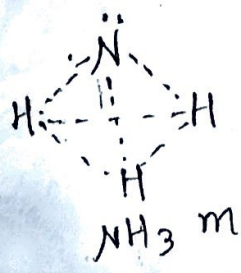
Ans: The bon angle among CH_4, NH_3 and H_2O are given below.

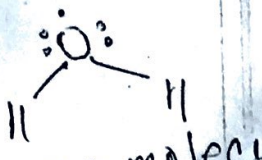
$CH_4 \rightarrow 109.5^\circ$

$NH_3 \rightarrow 107.5^\circ$

$H_2O \rightarrow 104.5^\circ$


CH_4 molecules


NH_3 molecule


H_2O molecules

In the case of CH_4 has no lone pair of electron ∴ No repulsion force of acted. Therefor The formation CH_4 molecule is tetrahedral and the bond angle ac CH_4 molecule is 109.5°.

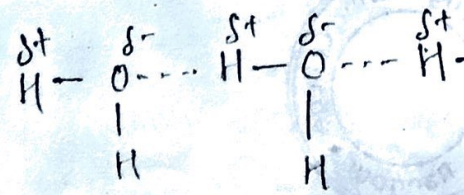
But in case of NH_3 and H_2O atom we can from their orbital illustration that there is one and two lone pair electron in NH_3 and H_2O ad

For the repulson force of lone pair elect the CH_4, NH_3 and H_2O molecule have different bon angle.

39. Q. H_2O is liquid while H_2S is a gas-explain wh

Exm: 2003.

Ans: In H_2O molecule O is very high electro negative then H- atom. For this case there is a hydrogen bonding between two H_2O molecule and it is much stronger than any other dipole-di interaction. So H_2O is liquid.

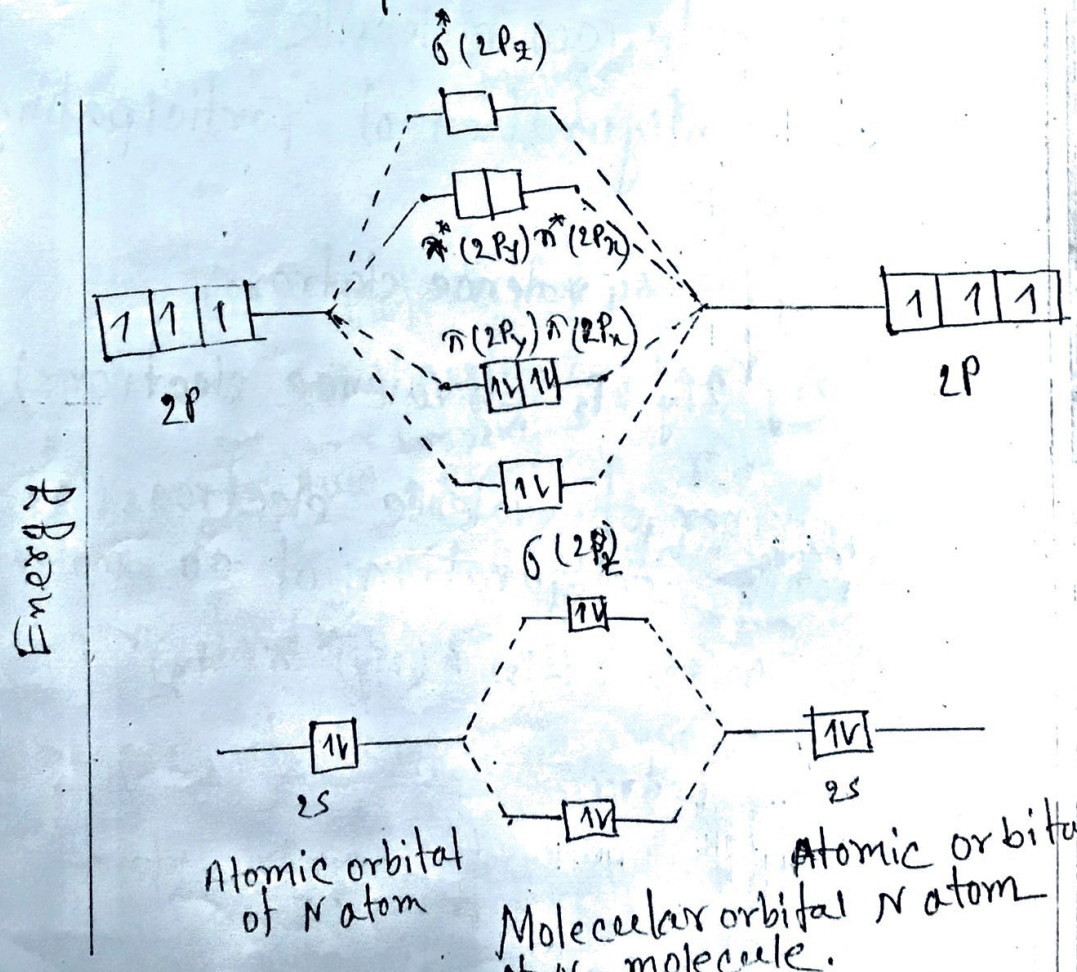


In case of H_2S molecule the electronegativity of H and S atoms is approximately same. so there is no hydrogen bonding in H_2S molecule and the molecule stay apart from another. so H_2S is gas.

Q. He_2^+ exists while He_2 does not? Explain why?
Exam: 2002.

40s Q. Using molecular orbital (MO) theory find out the number of electrons in each of the molecular orbital of N_2 molecules calculate its bond order. Exm: 2005.

Ans: Each of the two N- atoms ($1s^2, 2s^2, 2p_x^1, 2p_y^1, 2p_z^1$) contribute $(2+1+1+1)=5$ valence electrons and four atomic orbitals towards the molecule. The molecule whould have eight molecular orbital and ten ~~atomic~~ electron to be accomimoder in them. The electronic configuration in the molecules is represented as.



There are eight electrons in the bonding molecular orbital and only two in intibonding orbital.

Thus

This gives the number of bonds $\frac{1}{2}(8-2)=3$. The two N atoms are bonded with three covalent bonds. ie a tripole bond. N_2 molecule is dimagnetic as it has no unpaired electron.

Ar Q. Give the electronic configuration of CO, NO and calculate their bond order. Exm: 2005, 2006.

Ans:

Carbon Monoxide (CO) molecule:

The electronic configuration of participating C and O atoms are.

$C = 1s^2 2s^2 2p_x^1 2p_y^1 2p_z^0$ (4 valence electrons)

$O = 1s^2 2s^2 2p_x^2 2p_y^2 2p_y^1 2p_z^1$ (6 valence electrons).

The total number of valence electrons is 10 and the eight molecular orbital electronic configuration of CO molecules

$CO = KK\ \sigma(2s)^2\ \sigma^*(2s)^2\ \sigma(2p_z)^2\ \pi(2p_y)^2\ \pi(2p_x)^2$.

The bond order $= \frac{N_b - N_a}{2} = \frac{1}{2}(8-2) = 3$

This shows that carbon and oxygen atom in CO

On the other hand He_2^+ have the configuration is! For forming He_2, the molecular orbitals requir $\sigma(1s)$ which have accommodate two ~~four~~ electrons. Each one of these molecular orbital would accom odate two electrons as ~~hows~~ shown below

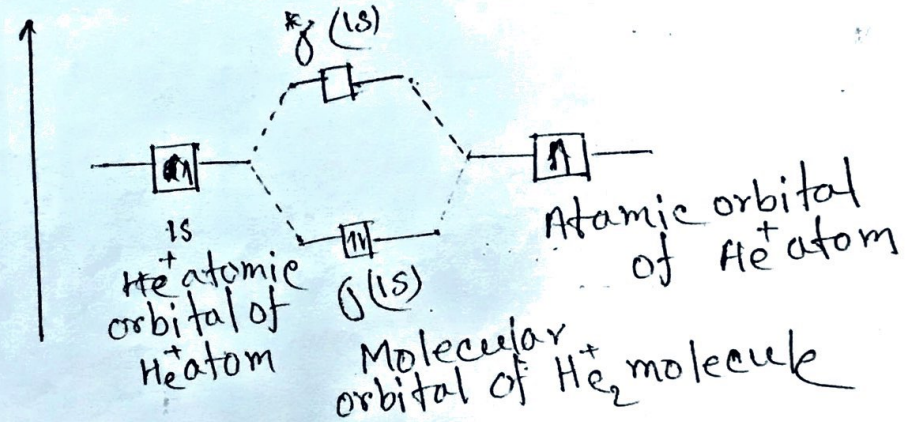


Fig: Molecular orbital diagram for He molecule.

It has ~~to~~ two bonding electron and no antibondig electron.

Thus bond order ~~=~~ $He_2^+ = \frac{1}{2}[2-0) = 1$.

Hence it is exist and bonded one singl bond.

so we can say He_2^+ exist while He_2 does no exist.