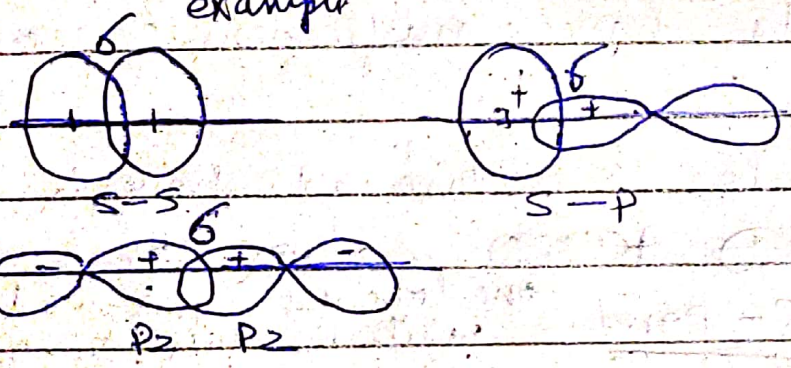
Chemical bonding

Types of Bonding: — (syllabus) σ, π, τ, δ bonds, Bonding in B_2H_6, Copper acetate and Chromous acetate, Concept of Resonance and delocalisation of orbitals e.g. NO, NO_3^-, SO_2, SO_3, SO_4^-, $PO_4^=$ and $CO_3^=$ ions, Hydrogen bond and related problems.

σ Bond

σ bond is formed by the overlap of orbitals along their axes (end to end overlapping or head to head overlapping

example



Properties

(a) Since the extent of overlapping of orbitals along the same axes is always greater than the extent of overlapping at an angle, σ bond is stronger than π Bond.

(b) electron cloud of σ Bond is symmetrical about the line joining the two nuclei. So, free rotation of atoms around the σ-bond is possible.

(c) There can be free rotation of the atom around the σ bond. Such types of

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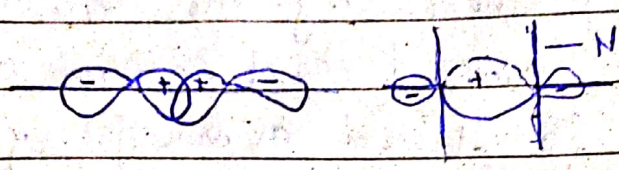
is not possible in π bond, since the electrons overlap above and below the plain.

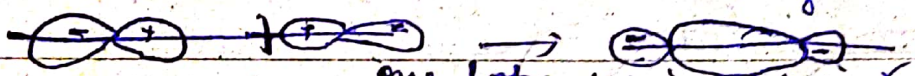
(d) σ-Bond determines the direction of the bond and extent of internuclear distance. shape is determines the shape and geometry.

(e) Nodal planes, if any, are perpendicular to the bond axis.

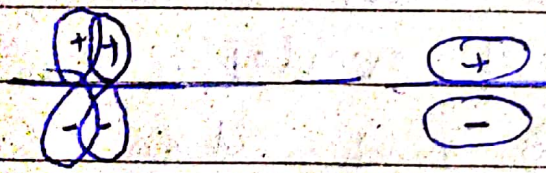


(f) σ-bonds have independent existence.

(g) σ - less reactive and strong bond.

(h) 

(1) π-bond is formed by the sidewise overlap of atomic orbitals



(2) The π-bond is formed by P and d orbitals

(3) π Bond is weaker and more reactive.

(4) free rotation of atoms is not possible

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(5) Nodal plane is parallel to the plane of bond axis

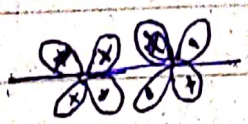
(6) π bonds do not influence the shape and geometry of molecule.

(7) π bond exists after existance of σ-Bond and bond angle reduces due to repulsion of lone pair

(8) Both lobes of p-orbital taking part in π-Bond formation remain of the same size.

δ-Bond

The two d-orbitals dx^2-y^2 and dx^2-y^2 combine to produce bonding and antibonding MOs which are called δ and δ^* respectively. On rotating these orbitals about the internuclear axis the sign of the lobes changes four times.



τ Bond or Banana bond

This is found in electron deficient compound. There are not sufficient valency electron to form the expected no. of covalent bond.

As for example — B_2H_6.

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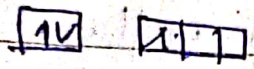
As we know electronic config. of B:-

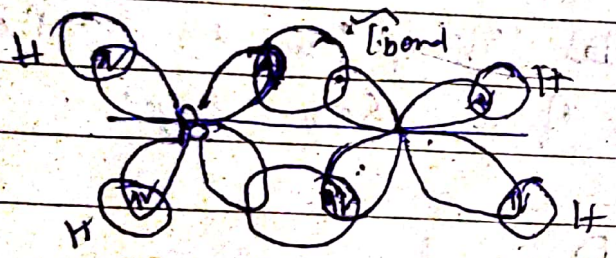
$1s^2 | 2s^2\ 2p^1$
V.E

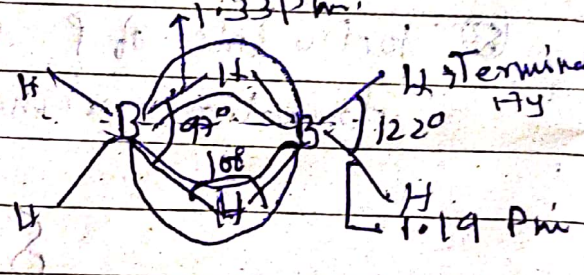
Boron — G.S.



Excited state

sp^3 hybridization takes place in orbitals. hybridized.





Four hydrogen left and right side are known as Terminal hydrogen and two other hydrogen atoms are known as bridging hydrogen. Two hydrogen and one Boron left and two hydrogen and one Boron left i.e 4 hydrogen and two B-atom lies on a plane while two bridging hydrogen atoms lie on a plane perpendicular to this plane. The above bridge structure confirmed by these facts.

(1) electron diffraction measurements confirm that four terminal Hydrogen atoms are coplanar and the two bridging hydrogen atoms occupy above and below plane

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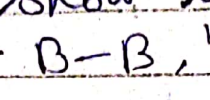
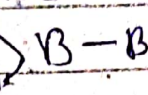
2. Vibrational spectrum (Raman and infrared) Studies show two intense bands at 2012 cm^{-1} and 2523 cm^{-1} for B–H atoms. This indicates that all the six hydrogen are not identical.

3. NMR show three main region absorption. B–B,  , 

4. Specific heat of diborane found to be 54.4 KJ while the ethane is 12.5 KJ.
This indicate that there is hindrance of rotation of Diborane that is due to bridge structure.

5. Diborane on methylation gives $B_2H_2(CH_3)_4$ shows 4 – H atom are different in reaction.
This is also example of 3 Centred 2 electron (3c – 2e).
Banana bond or τ Bond is larger than covalent bond.

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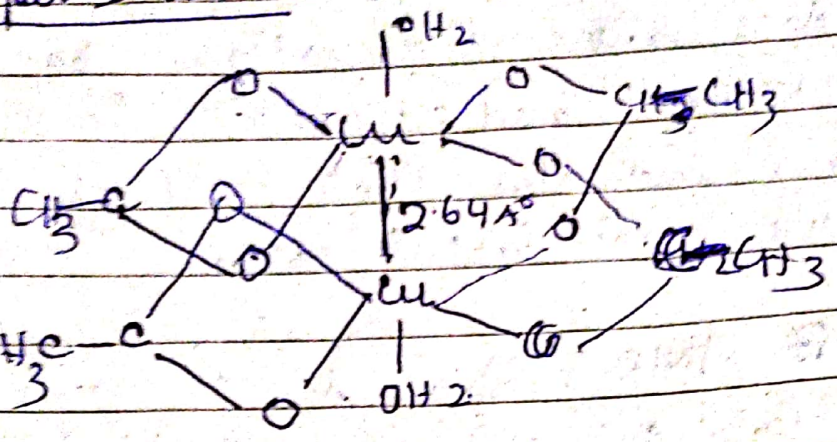
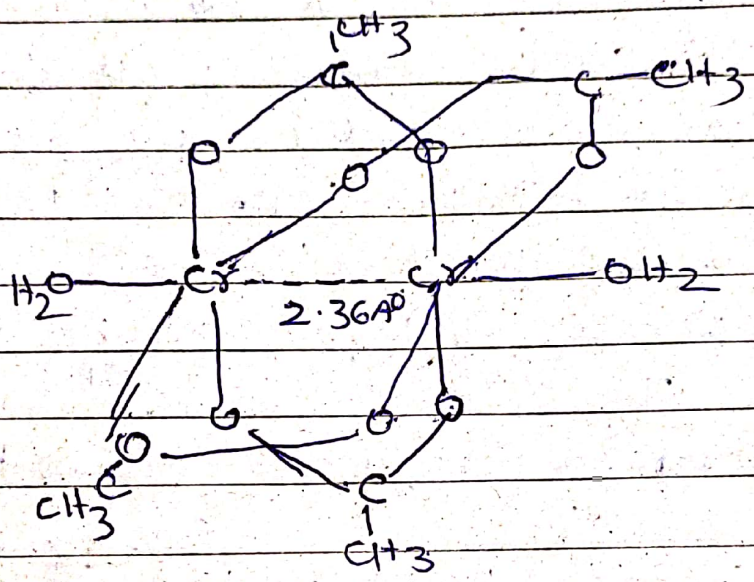
Copper II acetate ($Cu_2(CH_3COO)_4 \cdot 2H_2O$.



Cu (II) acetate is dimer and hydrated $Cu_2(CH_3COO)_4 \cdot 2H_2O$ .. The structure consists of two Cu atoms each with a roughly octahedral structure. The four acetate group act as bridging ligands. The two Cu - atoms Cu - Cu - distance is 2.64 A°.. Cu does not form a M - M (metal-metal) bond. The Cu (II) ion in complex have a d^9 configuration with one unpaired electron. If the two Cu - ions form a metal - metal bond these electron will be paired and the complex will diamagnetic. The magnetic moment measured at 25°C is 1.4 B.M. per Cu atom rather than Spin only value of 1.73 B.M. This suggest that there is weak coupling of unpaired

Spin on the two Cu-atom in the complex. This involves lateral overlap of the dx^2-y^2 orbitals on the Cu-atom which is known as δ bonding.

Chromium acetate



The structure is almost like Cu(II) acetate. The one big difference is Cr form M-M bond between two Cr ion because bond length is 2.36 Å° which shorter and can form M-M bond and thus diamagnetic.

Four acetate group bridge in chromium acetate. Ligands using one S, 3P and dx^2-y^2 and dz^2 orbitals. dz^2 form σ Bond to another Cr. dxz and dyz form π bonding between two Cr atoms. dxy form δ bond