Answer on the question #54657 – Chemistry – General chemistry

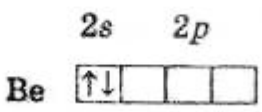
Question:

(a) Explain the shape of BeF2 molecule based on the hybridization concept and
VSEPR theory.
(b) Identify the type of hybridization of the carbon atoms in the following compound:

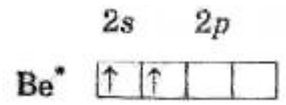
CH2 = CHCOCH3 (5)
Also predict the carbon-carbon and carbon-hydrogen bond length

Answer:

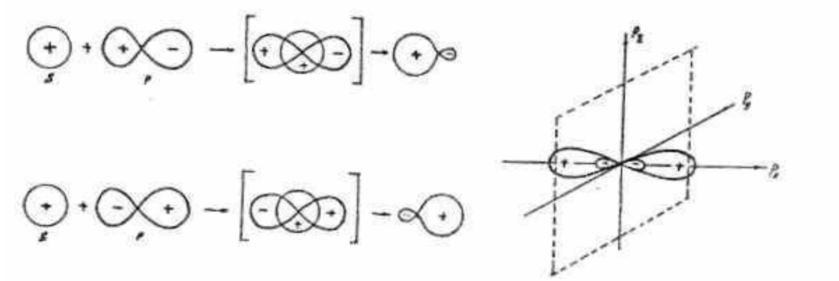
(a) To understand the BeF_2 molecule from the side of hybridization concept, let's consider the electronic structure of the molecule.
Be atom is situated in the second period and second group of the Periodic system of elements. In neutral state, it doesn't have unpaired electrons. Symbolic representation of the electron shell is: $1s^2 2s^2$
Then, let's consider bonding character of *Be* with *F* atoms. Certainly, the number of the bonds is two, and these two bonds are equivalent, i.e. we can't distinguish between different Fluor atoms.
Let's look on the orbital structure of *Be*:



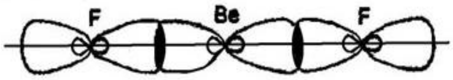
The two electrons are paired and can't form bonds. To take part in bonding, the Be atom is excited:



Thus, the two electrons are situated on different orbitals, hence their energy is different.
But we have already said that the bonds in BeF_2 are equivalent. So, the mathematical model of hybridization will provide us with the explanation.
Hybridization model tells us, that instead of two 2p and 2s orbitals, two new sp orbitals are formed. These sp orbitals are equivalent and have the same energy. The shape of these two orbitals is special:



Evidently, the space orientation of these orbitals is anti-parallel that predicts linear structure of BeF_2 molecule.



VSEPR theory is predicting the shape of the molecule, using the information about the number and character of electron pairs in the molecule. Thus, the different classes of molecules are formed, and each class corresponds to certain geometric organization of the molecule.

Considering BeF_2 molecule, we can notice that it is one of the class AX2E0. It doesn't have lone electronic pairs, the whole number of electronic pairs it 2. Thus, VSEPR theory predicts linear structure of the BeF_2 molecule.

(b) When considering the organic compounds, one should mention different possible hybridization states of carbon atoms in the molecule. Thus, let's give the numbers to the carbon atoms and consider them separately:
$C^1H_2 = C^2HC^3OC^4H_3$
Beginning with the first carbon atom, one can note 3 sigma-bonds and one pi-bond. These sigma-bonds are equivalent, then the corresponding type of hybridization is sp^2.
The same situation is exhibited by the second and third carbon atom, that also have 3 sigma-bonds and one pi-bond and hence sp^2 type of hybridization.
The fourth atom of carbon has 4 sigma-bonds, and evidently, the type of hybridization is sp^3.
Depending on the type of hybridization, the bond length can be predicted. This value is dependent on many factors, and the essential ones are type of hybridization and bond order. Considering the single bonds, they shorten slightly with the increase of s-character of carbon orbitals: from sp^3 to sp the bond is shortening from 1.09 to 1.06 A. Moving to the second factor (bond order), the effect is evident: the increase in bond order is shortening the bond.
In regard of all told above, one can see that:
1 carbon– sp^2 hybrid.: C–H bond length is 1.086 A, C=C bond length is 1.34 A (sp^2-sp^2 double bond)
2 carbon – sp^2 hybrid.: C–H bond length is 1.086 A, C^2–C^3 bond length is 1.54 A
3 carbon– sp^2 hybrid.: C–O bond length is 1.34 A (sp^2-sp^2 double bond), C^3–C^4 bond length is 1.54 A
4 carbon – sp^3 hybrid.: bond C–H length is 1.09 A.