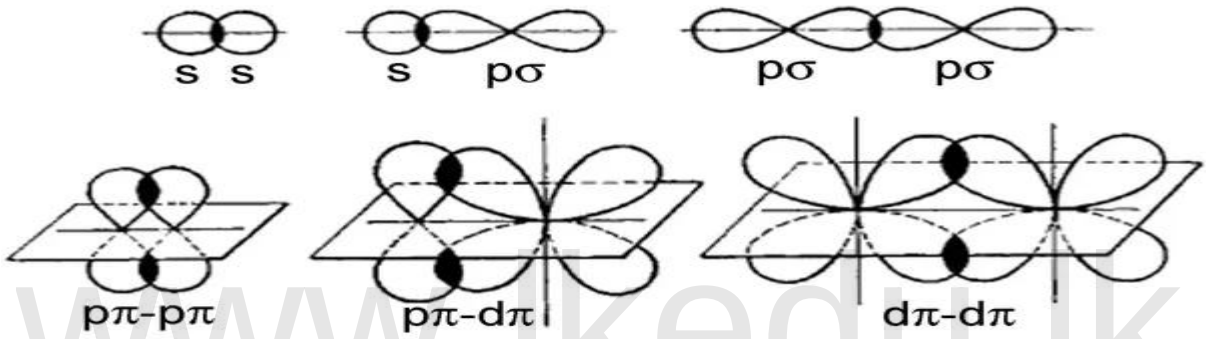
A.AravinthanBsc(Hons)Spl.Chem,PGDE

Hybidization

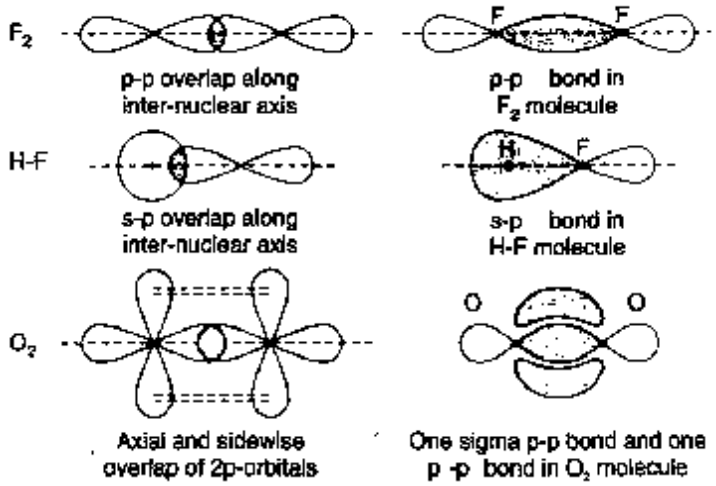
The main postulate of this theory are as follows

- A covalent bond is formed by the over lapping of two halt tilled valance atomic orbital of two different atoms.
- The electron in the over lapping orbital's get paired and confined between the nuclei of two atom.
- The electron density between the two bonded atoms increase due to the over lapping.
- Greater the extent of over lapping stronger is the bond formed.
- The direction of the covalent bond is along the region of over lapping of the atomic orbital's covalent bond is directional. there are two types of over lapping
    - Direct/ linear over lapping ---sigma bond is formed
    - lateral / parallel overlapping—pi bond is formed

Sigma Bond	*Pi Bond*
1. This bond is formed by the axial overlap of atomic orbitals.	1. The bond is formed by the sidewise overlap of atomic orbitals.
2. This bond can be formed by overlap of *s*-*s*, *s*-*p* or *p*-*p* orbitals.	2. It involves of overlap of *p*-orbitals only.
3. The bond is stronger because overlapping can take place to a larger extent.	3. The bond is weaker because the overlapping occurs to a smaller extent.
4. The molecular orbital is symmetrical about the internuclear axis and consists of single charged cloud.	4. The molecular orbital is discontinuous and consists of two charged clouds above and below the plane of atoms.
5. There can be a free rotation of atoms around the σ bond.	5. Free rotation of atoms around π bond is not possible because it involves breaking of π bond.
6. The bond may be present between the two atoms either alone or alongwith π bond.	6. The bond is always present between the two atoms alongwith the sigma bond, *i.e.*, it is always superimposed on sigma bond.
7. The shape of molecule is determined by the sigma frame work around the central atom.	7. The π bonds do not contribute to the shape however they modify the dimensions of the molecule.



www.ikedu.lk



Strength of three types of sigma bonds. The strength of three types of sigma bonds varies as follows: p–p > p–s > s–s

It is because of the fact, that p–orbitals allow overlap to greater extent as compared top–s which is larger as compared to s–s overlap.

Hybridization • Hybridization is a term used to describe the mixing of atomic orbitals to generate a set of new hybrid orbitals that are equivalent.

• It is a mathematical tool that allows us to relate the bonding in a molecule to its symmetry.

• A hybrid orbital results from the mixing of different types of atomic orbital on the same atom.

• The hybridization type can be determined from the number of electron domains around the central atom.

• The sublevels of the atom's valence shell recombine into new orbitals with different shapes and angles:

osp hybridization:

§ mixture of one s orbital and one p orbital
§ results in two degenerate (equivalent – same energy) orbitals
§ are at an angle of 180° from each other
§ have a linear shape, with two unhybridized p orbitals

o sp2 hybridization:

§ mixture of one s orbital and two p orbitals
§ results in three degenerate orbitals
§ are at angles of 120° from each other
§ have a trigonal planar shape, with one unhybridized p orbital

o sp3 hybridization:

§ mixture of one s orbital and three p orbitals
§ results in four degenerate orbitals § are at angles of 109.5° from each other
§ have a tetrahedral shape

ARAVIN
www.lkedu.lk

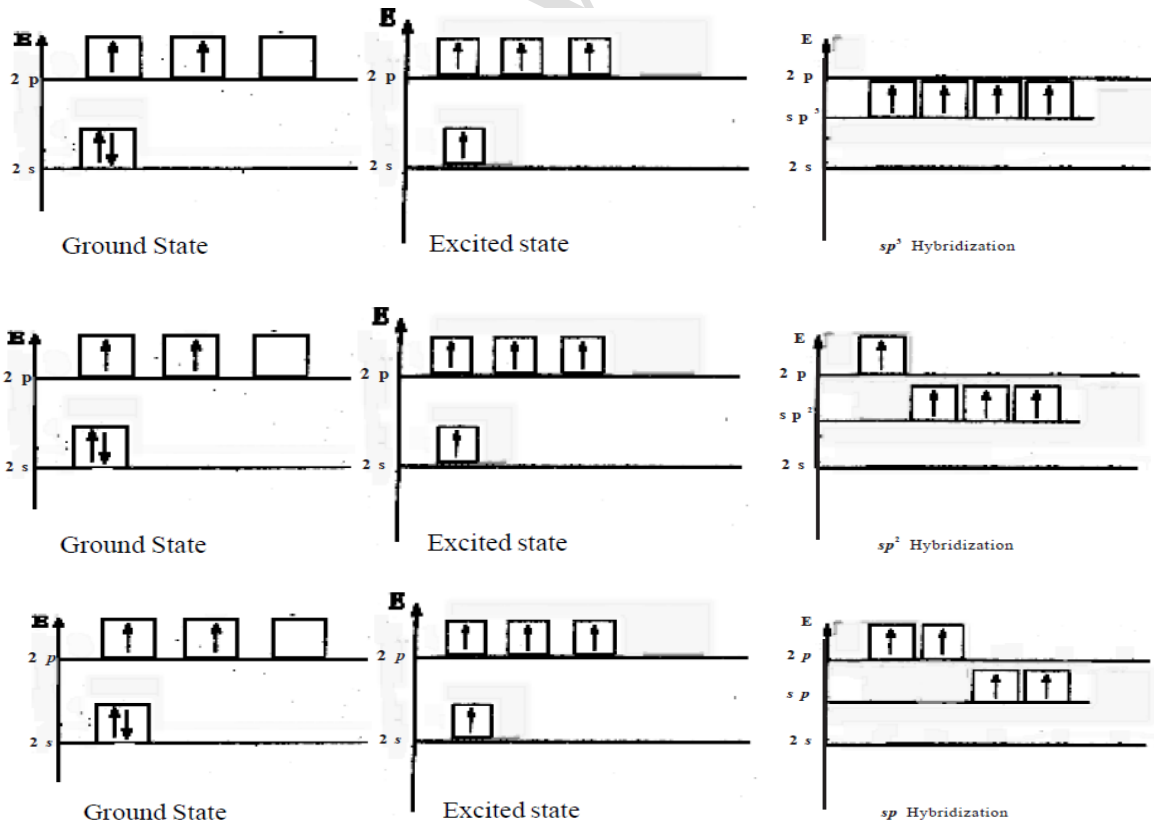
o sp3d hybridization:

§ mixture of one s orbital, three p orbitals, and one d orbital
§ results in five degenerate orbitals
§ three are at 120° from each other on the equatorial plane, and two are 90° to the plane (axial) but 180° from each other
§ have a trigonalbipyramidal shape

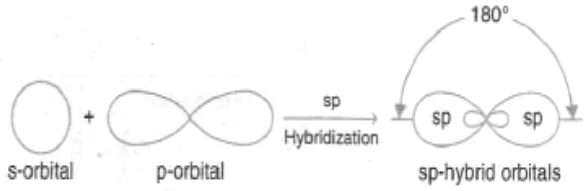
o sp3d2 hybridization:

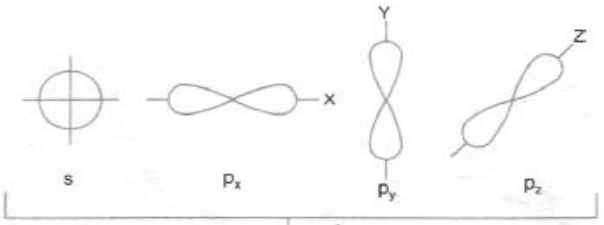
§ mixture of one s orbital, three p orbitals, and two d orbitals
§ results in six degenerate orbitals § are at angles of 90° from each other
§ have an octahedral shape.

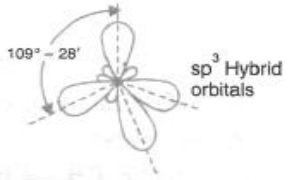
 The electronic configuration of C in its ground state is $1s^2\ 2s^2\ 2p^2$. According to the electronic configuration of C in its ground state, the carbon atom has only two unpaired electrons.
 But when a C atom form CH_4, it makes four bonds which are all equivalent. To understand this, it is considered that the electrons of the C atom attain the excited state and then proceed to the process of hybridization.
 Here, the hybridization takes place after an electron from the 2*s* sub energy level of C transits into an empty 2*p* orbital.
 How the C-C single bonds, C = C double bonds and triple bonds are formed can be explained using the C atom with excited electrons undergoing sp^3 or sp^2or *sp*hybridizations respectively.
 The differences in energy among the various orbitals of the valency shell of the carbon atom in the ground state, excited state and in hybridized state are given below comparatively.

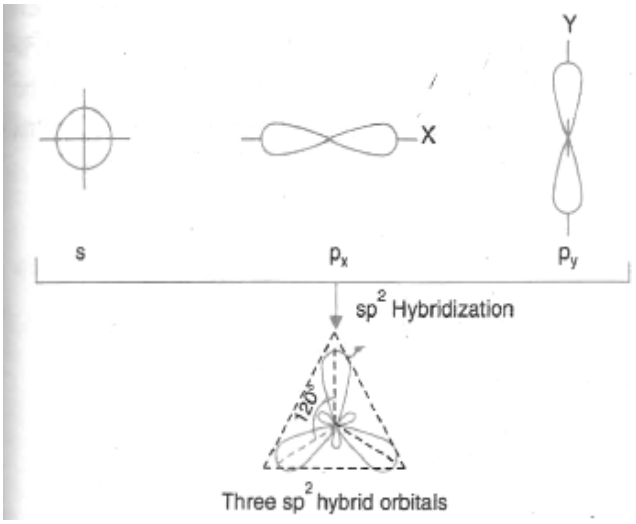


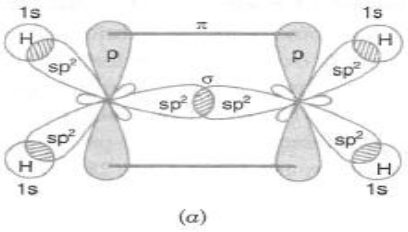
VINTHAN
www.lkedu.lk

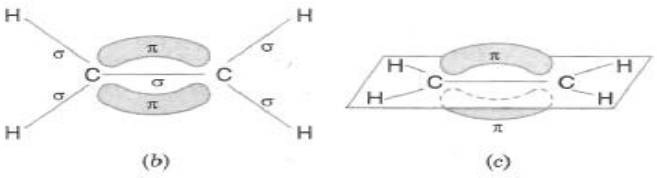

180°
sp
Hybridization
sp
sp
s-orbital
p-orbital
sp-hybrid orbitals

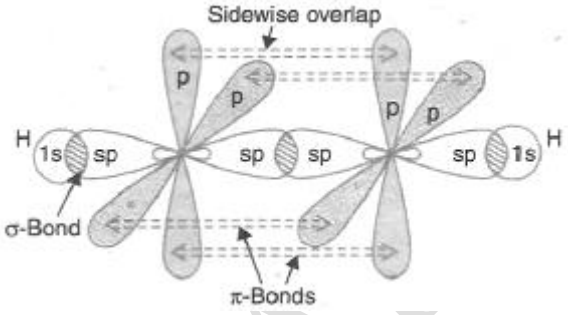

Y
Z
X
s
p_x
p_y
p_z
sp^3 Hybridization

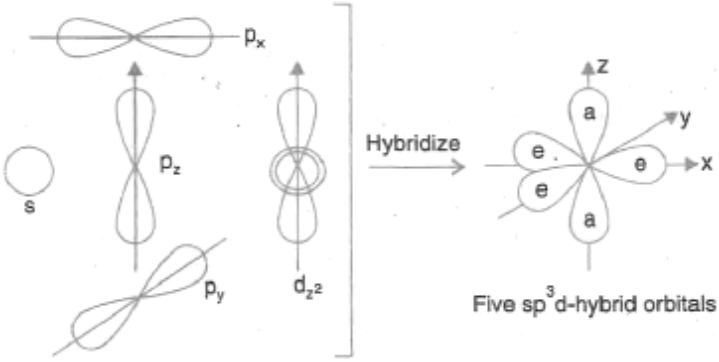

109° - 28'
sp^3 Hybrid orbitals

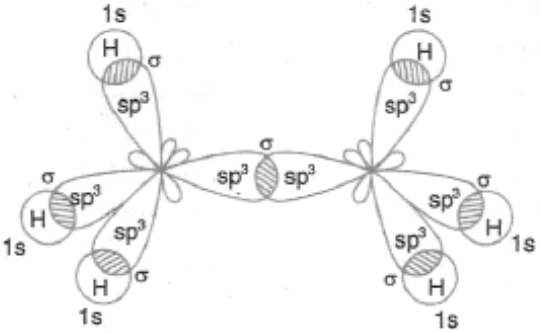

Y
X
s
p_x
p_y
sp^2 Hybridization
120°
Three sp^2 hybrid orbitals

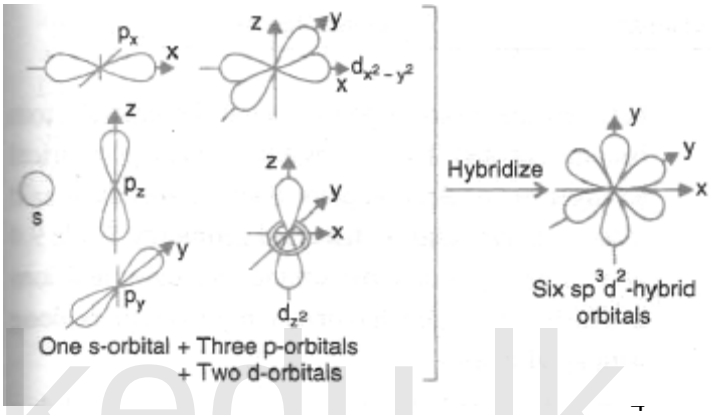

1s
H
sp^2
p
π
σ
1s
H
sp^2
p
sp^2
sp^2
sp^2
sp^2
H
1s
H
1s
(a)

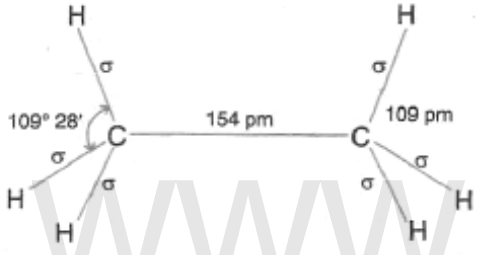

H
σ
π
σ
C
σ
C
π
H
(b)
H
π
H
C
C
H
H
π
(c)


Sidewise overlap
p
p
p
p
H
1s
sp
sp
sp
sp
1s
H
σ-Bond
π-Bonds


p_x
p_z
s
p_y
d_{z^2}
Hybridize
z
a
y
e
e
x
e
a
Five sp^3d-hybrid orbitals


1s
H
σ
sp^3
1s
H
σ
sp^3
σ
sp^3
sp^3
σ
sp^3
H
1s
sp^3
sp^3
H
1s
H
σ
σ
H
1s
1s

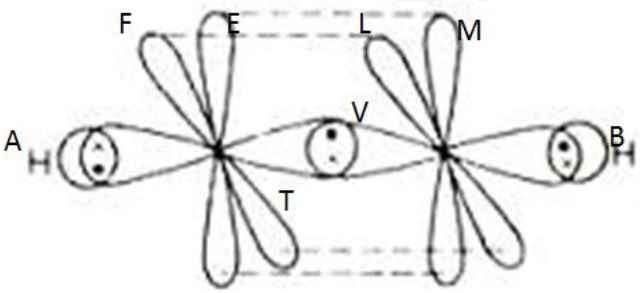

p_x
x
z
y
$d_{x^2-y^2}$
x
z
p_z
s
y
p_y
z
y
x
d_{z^2}
One s-orbital + Three p-orbitals
+ Two d-orbitals
Hybridize
y
y
x
Six sp^3d^2-hybrid orbitals

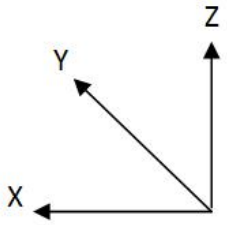

H
σ
H
σ
109° 28'
C
154 pm
C
109 pm
σ
σ
H
σ
σ
H
H
H

www.lkedu.lk

1) Consider the C_2H_4 molecule
    a. Name Specifically the orbital's that are being used by the carbon atomic for bond formation in this molecule
    b. Indicate in a diagram the orbital's that are being used by a carbon atom for bond formation in this molecule. Indicate clearly in your diagram the angle between the directions of orientation of the above orbital's. N.B there angle should be specified in degrees.
    c. Describe clearly the nature of the double bond between the two carbon atoms in the C_2H_4 molecule.

2) Consider the diagram shown below, pertaining to the formation of chemical bonds in the C_2H_2 molecule, In this diagram the various atomic orbital's relevant to the C_2H_2 molecule are drawn approximately.

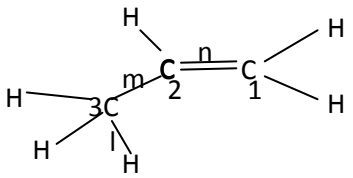




Examine the diagram given above, fill the blanks in the following sentences apporopriately.
N.B You should pay attention to the axes. In naming the various atomic orbitals specifically follow the method usually accepted for that purpose

a) A is …… orbital
b) T is …… orbital
c) L is …….. orbital
d) M is …….. orbital
e) Between T & V ……. takes place
f) Between F & M …… takes place

3) Consider the structure shown below. the three carbon atoms of the structure are labeled us 1,2,3. three of its bonds are labeled as l,m,n



Now write clearly the words&symbols appropriate for the vacant spaces at the relevant placesin the description presented below.description

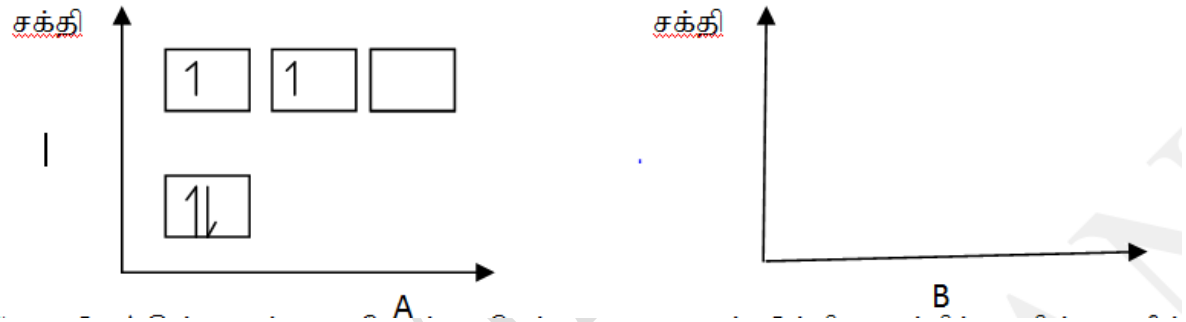
www.lkedu.lk

a) The C – H ,8 bond designated as l is formed by the …… of the …… orbital of the relevant it atom with an …… orbital of the relevant C atom.

b) The C – C bond designated as m is formed by the …….. of an …… orbital of the C atom labeled as 3, with an ……orbital of the atom labeled as 2

c) In the formation of the Z – bond of C –C designated as n, the …….. of the C, atom labeled as 2, containing one unpaired …….. of the C atom labeled as 1, containing one ……

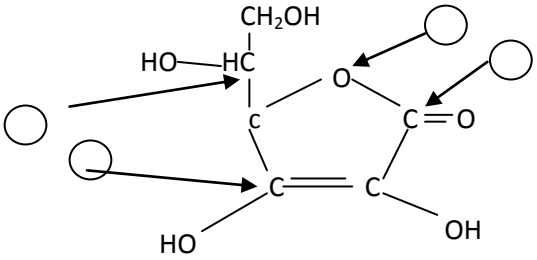
4) Consider the state of hybridization of the carbon atoms in the thence molecule C_2H_4 given below in cage A is the schematic respiration of the election distribution in the outer shell of the ground state carbon atom where each box represents an orbital.
N.B. There vertical position of the boxes represents the relative energy levels of the orbital's.



a) Using boxes similar to those in cage A, draw in cage B, the outer orbital's of a hybridized carbon atom in ethence label the boxes to indicate the types of orbital's represented by them. Indicate as in cage A the electron distribution in the boxes in cage B
N.B: In drawing these boxes in cage B, pay attention to their vertical position with respect to the boxes in cage A

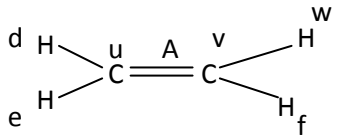
b) Complete the following sentences by filling in the blanks
i) The electron in the …… orbital of carbon is in valued in the formation of the π bond in C_2H_4
ii) The electrons in the …… orbital's of carbon are in valued in the formation of C – H bonds in C_2H_4

5) The molecular structure of vitamin C is given below. write the hybridization of the carbon and oxygen atoms indicated by arrows as SP,SP^2 or SP^3 in the appropriate circle.



www.lkedu.lk

6) consider the molecule A given below. Supercripts,d,e,f,w&w are used to level the H atom



Indicate whether each of these statements is correct (√)or wrong (X) in the appropriatebox. If you are unable to evaluate any of these statement keep the box vacant.

a) Carbon atom denoted by U is SP^2 hybridized ( )

b) Carbon atom denoted by **V** is SP^2 hybridized ( )

c) The double bond between C atoms denoted by U & V consists of a σ bond & a πbond ( )

d) A π bond is formed by the lateral overlap of two SP^2orbital's ( )

e) All the atoms in A lie in the Same plane ( )

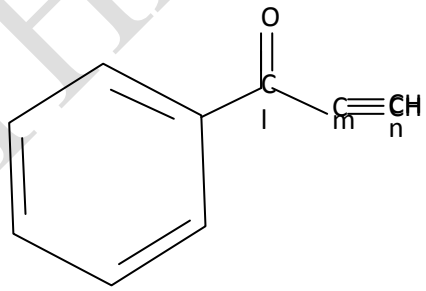
1. Which of the following statements is/are true regarding the molecule

a. All carbon atoms are SP^2 hybridized

b.Carbon atoms labeled as l,m,n and the Oxygen atom lie in the same plane

c.All C-H bond length are equal in length

d. Carbon atoms labeled as l,m,& n lie in a straight line



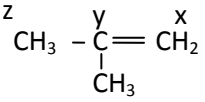
2.The correct statement regarding the structure of the following compound is / are?

a. Carbon atoms Labelled x,y&z lie on straight line

b.The angle between the C-H bonds on the carbon atom labeled as x is 160°

c. All four carbon atoms lie on one plane

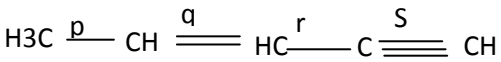
d.The distance between carbon atoms labelled x & y is less than the distance between carbon atoms labelled y & z.



3.Which of the following statements/statement concerning atiomic orbitals are /is true?

1. On overlap of two P orbital, a π bond is always formed
2. On overlap of and S orbital ,a P orbital, a σ bond is a π bond can be formed.
3. On overlap of two S orbitals , a , a σ bond is always formed
4. S& P orbital making part in Hybridization should belong to the same atom

4.Consider the following molecule



a. All Carbon atoms of this molecules lie in the same plane

b. All C-H bonds of the molecule are equal in length

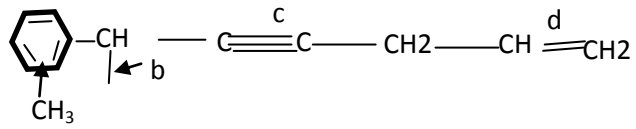
c. The carbon –Carbon bond lengths increased in the order S<Q<P<R

d. Three carbon atoms of this molecule are linearly arranged

ARAVINTHAN

www.lkedu.lk

5.Which arrangement gives the correct increasing order of bond lengths of the bonds labelled a,b,c,&d in the following



1.a<b<c<d 2. a<c<b<d 3.c<a<d<b 4.c<d<a<b 5. d<c<b<a

6. Which of the following molecule statements concerning the ethyne molecule is most appropriate

1. In the ethyne molecule is most there is one σ bond
2.In the ethyne molecule there are two σ bond
3.In the ethyne molecule there is one π bond
4.In the ethynemolecule,twoπ bonds are perpendicular to one another
5.In the ethyne molecule, the angle between the two planes of the two π bonds is 90̊

7.which one of the following statements is not true aqbout hybridization?

1. Hybrid orbitals formed from a given hybridizations have the same shape
2.Hybrid orbitals may be formed π bond
3.The angle between SP2 hybrid orbitals is 120̊
4. All carbon atoms in hydrocarbons are hybridized
5.Hybrid orbitals formed from a given hybridization have the same energy.

8.Of those given below the possible combination of bonds that can be formed between any two atom is ?

1. twoσ bond& one π bond 2.threeσ bond 3. oneσ bond& one π bond
4.threeπ bond 5.twoσ bonds

Number of electron pairs around central atom		Full description of the molecule					
BONDING (E)	LONE (E)	Example	Bond angles °	Geometry of Electron Pairs	Geometry of Atoms	3D Shape	Type
2	0	$BeCl_2$	180	Linear	**Linear**		AB_2
3	0	BF_3	120	Trigonal planar	**Trigonal Planar**		AB_3
2	1	SO_2	Slightly less than 120	Trigonal planar	**Bent or V Shaped**		AB_2E
4	0	CH_4	109.5	Tetrahedral	**Tetrahedral**		AB_4
3	1	NH_3	107.5	Tetrahedral	**Trigonal Pyramidal**		AB_3E
2	2	H_2O	104.5	Tetrahedral	**Bent or V Shaped**		AB_2E_2
5	0	PCl_5	120 in plane. 90 perpendicular to plane	Trigonal bipyramidal	**Trigonal Bipyramidal**		AB_5
4	1	SF_4	Complex	Trigonal bipyramid	**Seesaw**		AB_4E
3	2	ClF_3	Approx. 90	Trigonal bipyramidal	**T-Shaped**		AB_3E_2
2	3	XeF_2	180	Trigonal bipyramid	**Linear**		AB_2E_3
6	0	SF_6	90	Octahedral	**Octahedral**		AB_6
5	1	BrF_5	Approx. 90	Octahedral	**Square Pyramidal**		AB_5E
4	2	XeF_4	90	Octahedral	**Square Planar**		AB_4E_2

VINTHAN

www.lkedu.lk