

Section 4.6: Quantum Mechanics and Bonding: Hybridization

Section 4.6 Questions, page 238

1. The hybrid atomic orbitals in a molecule of phosphine, PH_3 , are sp^3 hybrid orbitals.

Phosphorus:



2. A sigma bond forms from the direct, head-on overlap of two molecular orbitals, and a pi bond forms from the overlap of the lobes of two parallel molecular orbitals.

3. The bonding in elemental oxygen involves the overlap of a p orbital from each atom to form one sigma bond and the overlap of another p orbital from each atom to form one pi bond. No orbital hybridization is required.

4. (a) The three-dimensional structure that results from sp orbitals is linear.

The three-dimensional structure that results from sp^2 orbitals is trigonal planar.

The three-dimensional structure that results from sp^3 orbitals is tetrahedral.

(b) Of the hybrid orbitals sp , sp^2 , and sp^3 , only sp and sp^2 can form multiple bonds.

5. The atoms in a single bond can rotate about the central axis without breaking the sigma bond. The bonds in a double or triple bond break when the central axis is rotated because the rotation of the atoms about a central axis disturbs the overlap of the parallel orbitals involved in a pi bond(s), causing the double or triple bonds to break.

6. (a) Hybridization of CO: sp

Three-dimensional structure of CO: linear

(b) Hybridization of H_2CO : sp^2

Three-dimensional structure of H_2CO : trigonal planar

(c) Hybridization of SiF_4 : sp^3

Three-dimensional structure of SiF_4 : tetrahedral

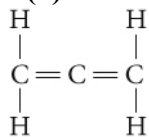
7.

	(a)	(b)	(c)	(d)	(e)	(f)	
							Orbital diagrams
Atom	Electron configuration	Valence electrons	Excited-state atom	Hybrid orbitals	Orbitals available for bonding	Orbital used to form sigma bonds	
	hydrogen	$1s^1$	1s ↑	does not need to promote electrons	none	1	1s
(i)	boron	$[\text{He}] 2s^2 2p^1$	2p ↑ □ □ 2s ↑↓ □ □	2p ↑ ↑ □ 2s ↑	2p ↑ ↑ □ 2s ↑ sp^2 ↑ ↑ ↑	3	sp^2
(ii)	silicon	$[\text{Ne}] 3s^2 3p^2$	3p ↑ ↑ □ 3s ↑↓	3p ↑ ↑ ↑ 3s ↑	3p ↑ ↑ ↑ 3s ↑ sp^3 ↑ ↑ ↑ ↑	4	sp^3
(iii)	nitrogen	$[\text{He}] 2s^2 2p^3$	2p ↑ ↑ ↑ 2s ↑↓	does not need to promote electrons	2p ↑ ↑ ↑ 2s ↑↓ sp^3 ↑ ↓ ↑ ↑ ↑	3	sp^3
(iv)	chlorine	$[\text{Ne}] 3s^2 3p^5$	3p ↑↓ ↑↓ ↑ 3s ↑↓	does not need to promote electrons	3p ↑↓ ↑↓ ↑ 3s ↑↓ sp^3 ↑ ↓ ↑ ↓ ↑	1	sp^3

8. (a) The hybridization of the central S atom in H_2S is sp^3 .(b) The hybridization of the central C atom in CCl_4 is sp^3 .(c) The hybridization of the central N atom in NCl_3 is sp^3 .(d) The hybridization of the central C atom in CO_2 is sp .(e) The hybridization of the N atoms in N_2 is sp .(f) The hybridization of the B atoms in B_2F_4 is sp^2 .9. (a) In the benzene molecule, the hybridization of each C atom is sp^2 .(b) You would expect a bond angle of 120° in the benzene molecule.

10. The statement "A triple bond forms from a pi bond and 2 sigma bonds. In the molecule HCN, the sp^3 hybrid orbital of carbon results in a tetrahedral shape" is not correct. The statement misrepresents the numbers of pi and sigma bonds that form a triple bond. The statement should read "A triple bond forms from 2 pi bonds and 1 sigma bond. In the molecule HCN, the sp hybrid orbital of carbon results in a linear shape."

11. (a) The Lewis structure of propadiene is



(b) The type of hybrid orbitals involved on the end carbon atoms are sp^2 orbitals, because the end carbons are involved in 3 sigma bonds and 1 pi bond.

(c) The shape about the end carbon atoms will be trigonal planar.