Chapter 9 and 10: Bonding, General Concepts

1. The correct statement is: (a) water is linear  (b) the molecule ClO₂ cannot be accurately described by Lewis structure consistent with the octet rule (c) the bonds in LiF have more covalent character than those in F₂  (d) all of these are false

2. How many of the following molecules or ions are linear? NH₃, NH₄⁺, HCN, CO₂, NO₃⁻  (a) 0 (b) 1 (c) 2  (d) 3 (e) 4

3. Which of the following species has a trigonal bipyramidal structure? (a) NH₃  (b) IF₅  (c) I₃⁻  (d) PCl₅ (e) none of these

4. What is the molecular structure of XeF₄? (a) linear  (b) tetrahedral  (c) square planar (d) octahedral

5. Give an example of each: Polar Covalent Compound, 100% Covalent Compound, Ionic Compound. What one factor causes the bonding type to change

6. Which contains the most polar bond: HBr, HCl, or HF?

7. As the bond order for a carbon-carbon bond increases, which one of the following decreases? (a) number of electrons between the carbon atoms  (b) bond energy  (c) bond length  (d) number of pi bonds  (e) none of these

8. Which of the following groups contain no ionic compounds? (a) HCN, NO₂, Ca(NO₃)₂  (b) PCl₅, LiBr, SF₄  (c) KOH, CCl₄, SF₄  (d) NaH, CaF₂, NaNH₂  (e) CHO₂, H₂S, NH₃

9. Using the concept of formal charge, which electron dot formula most accurately describes the bonding of CS₂?

   a)  \( \ddot{C}==\ddot{S} \)  
   b)  \( \dddot{S}−\dddot{C}−\dddot{S} \)  
   c)  \( \dddot{S}−\dddot{C}==\ddot{S} \)  
   d)  \( \dddot{S}==\ddot{C}==\ddot{S} \)  
   e)  \( \dddot{S}−\dddot{C}≡\dddot{S} \)
10. Which of the following molecules exhibit resonance?  PF$_5$, SO$_2$, O$_3$, SO$_4^{2-}$  
\[ (a) \text{PF}_5, \text{SO}_2, \text{O}_3, \text{SO}_4^{2-} \] 
\[ (b) \text{PF}_5, \text{SO}_4^{2-} \] 
\[ (c) \text{SO}_2, \text{O}_3 \] 
\[ (d) \text{O}_3 \] 
\[ (e) \text{SO}_4^{2-} \]

11. Which of the following violates the octet rule: I. BF$_3$  
II. CHBr$_3$ (C is central)  
III. Br$_2$  
IV. XeCl$_2$  
V. CO  
VI. SF$_4$  
\[ (a) \text{I,II,IV} \] 
\[ (b) \text{I,III,IV,VI} \] 
\[ (c) \text{III,V,VI} \] 
\[ (d) \text{I,IV,VI} \]

12. What is $\Delta H$ for the reaction:  Br$_2$ + 3F$_2$ → 2BrF$_3$.  Bond dissociation energies are as follows:  Br-Br = 192 kJ/mole,  F-F = 159 kJ/mole,  Br-F = 197 kJ/mole  
(Bond energies given on page 372 in text.)

13. Which of the following molecules or ions is not paramagnetic in its ground state?  
\[ (a) \text{O}_2 \] 
\[ (b) \text{O}_2^+ \] 
\[ (c) \text{B}_2 \] 
\[ (d) \text{NO} \] 
\[ (e) \text{F}_2 \] 
Use Molecular Orbital to determine the bond order of B$_2$ and predict if the molecule could exist.

14. Which of the following statements is/are false?  
\[ (1) \text{the hybridization of N in NH}_3 \text{ is sp}^2 \] 
\[ (2) \text{the hybridization of P in PCl}_5 \text{ is } \text{dsp}^3 \] 
\[ (3) \text{the bond order of N}_2 \text{ is three} \] 
\[ (4) \text{the molecule HCN has two pi and two sigma bonds} \] 
\[ (a) \text{all four statements are true} \] 
\[ (b) 2 \] 
\[ (c) 1, 4 \] 
\[ (d) 2, 3 \] 
\[ (e) 2, 3, 4 \]
15. Consider the Lewis structure for

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \\
\text{O} \\
\text{H} \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{H}
\end{array}
\]

The dots around O did not print. Please put 4 dots around the O in the above diagram.

Which statement about the molecule is false? (a) C-1 is sp\(^2\) hybridized (b) Oxygen is sp\(^2\) hybridized (c) the molecule contains 28 valence electrons (d) the molecule contains 1 pi and 11 sigma bonds (e) all statements are true

**Additional Advanced Questions**

16. The angles between sp\(^2\) orbitals are
   a) 45°
   b) 90°
   c) 109.5°
   d) 120°
   e) 180°

17. The hybrid orbitals used for bonding by Xe in the unstable XeF\(_2\) molecule are ___ orbitals.
   a) sp\(^2\)
   b) sp\(^3\)
   c) sp\(^3\)d
   d) sp\(^3\)d\(^2\)
   e) sp

18. Draw the Lewis structures of NO\(^+\), NO\(_2\)^\(-\), and NO\(_3\)^\(-\). Based upon a consideration of the Lewis structures, which of these should have the longest N–O bond, and which should have the shortest N–O bond?

<table>
<thead>
<tr>
<th></th>
<th>Longest bond</th>
<th>Shortest bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) NO(^+)</td>
<td>NO(_3)^(-)</td>
<td></td>
</tr>
<tr>
<td>b) NO(^-)</td>
<td>NO(_2)^(-)</td>
<td></td>
</tr>
<tr>
<td>c) NO(_2)^(-)</td>
<td>NO(_3)^(-)</td>
<td></td>
</tr>
<tr>
<td>d) NO(_3)^(-)</td>
<td>NO(_2)^(-)</td>
<td></td>
</tr>
<tr>
<td>e) NO(_3)^(-)</td>
<td>NO(^+)</td>
<td></td>
</tr>
</tbody>
</table>
19. Place the following molecules in order of increasing bond angle:
CH₄, XeF₄, H₂O, CO₂, SO₂

a) XeF₄ < CH₄ < SO₂ < H₂O < CO₂
b) CH₄ < XeF₄ < H₂O < CO₂ = SO₂
c) H₂O < CH₄ < XeF₄ < SO₂ < CO₂
d) SO₂ < CO₂ < CH₄ < XeF₄ < H₂O
e) XeF₄ < H₂O < CH₄ < SO₂ < CO₂

Rules for Drawing Lewis Dot Diagrams

1. Count the total number of valence electrons. (Roman Numeral at top tells valence electrons)
2. Hook all atoms to the central atom with single bonds and eight electrons around each atom except hydrogen which wants only two.
3. (a) If the dots in the drawing match the valence electrons, the drawing is correct.
   (b) If too few dots are used, add the extra dots to the central atom
   (c) If too many dots are used, erase two dots from each of two adjacent atoms and replace them with a bond between the two atoms. Electrons in bonds between atoms count for both atoms involved.
( I. Boron is an electron deficient atom and will have 6 dots instead of 8. (II) in oxygen-containing acids, the O’s hook to the central atom and the H’s hook to the O’s.)

How to identify Sigma(σ) and Pi(Π) bonds
All single bonds between atoms are sigma bonds. The second bond in a double bond and the second and third bond in a triple bond are pi bonds. In other words, single bonds are sigma, double bond (one pi and one sigma), and triple bond( two pi and one sigma).

For a Molecule to be Polar:
1. Must contain at least two different elements.
2. The center of positive and negative must not coincide.
( If the Lewis Dot diagram has one lone pair or if it contains three different element, the molecule will be polar. It the Lewis Dot drawing contains no lone pairs and the same element at each position, it will be nonpolar.)

Hybridization:
Count the things around the central atom. (Everything counts as one: single bond, double bond, triple bond, atoms, or lone pairs.) You must use one atomic orbital for each thing around the central atom. Your choice of atomic orbitals will always be one s orbital first, three p orbitals secondly, and five d orbitals last. Example: 4 things would need one s and three p= sp³. Five things would need one s, three p, and one d = sp³d.
VSEPR Geometries

"A" is the central atom; "X" is a bonded atom; "E" is a nonbonding pair of electrons

$AX_2$ Linear

$AX_3$ Trigonal Planar

$AX_2E$ Bent

$AX_4$ Tetrahedral

$AX_3E$ Pyramidal

$AX_2E_2$ Bent

$AX_3$ Trigonal Bipyramidal

$AX_4E$ Seesaw

$AX_3E_2$ T-shaped

$AX_2E_2$ Linear

$AX_5$ Octahedral

$AX_5E$ Square Pyramidal

$AX_4E_2$ Square Planar