

Chapter 9 Study Guide Answers

Outline

I. Valence Shell Electron Pair Repulsion Theory

A. Molecular Shapes

1. Molecules that obey the octet rule

2. Expanded Octets

B. Molecular Symmetry

1. Molecules that obey the octet rule

2. Expanded Octets

C. Molecular Polarity

1. Molecules that obey the octet rule

2. Expanded Octets

II. Valence Bond Theory

A. Hybridization

B. Sigma and Pi bonds

C. Delocalized Bonds

III. Molecular Orbital Theory

A. Electron density in association with sigma bonding, pi bonding, sigma antibonding, and pi antibonding

B. Relative energies of atomic versus bonding and antibonding electrons

Practice Problems

1. Draw the Lewis Structures, predict the geometries (shapes) and polarity of the following molecules.

a. PCl_3

**P single bonded to each Cl,
One lone pair electrons on P
Trigonal pyramidal
Polar**

b. CHCl_3

**C single bonded to H
C single bonded to each Cl
Tetrahedral
Polar**

c. CO_2

**C double bonded to each O

Linear
Nonpolar**

d. TeCl_4

**Te single bonded to each Cl
One lone pair electrons on Te
Seesaw/Rocking Horse
Polar**

e. OF_2

**O single bonded to each F
Two lone pairs electrons on O
Bent
Polar**

f. SF_6

**S single bonded to each F

Octahedron
Nonpolar**

g. BrF_5

**Br single bonded to each F
One lone pair electrons on Br
Square Pyramidal
Polar**

h. SeO_2

**Se single bonded to one O
Se double bonded to other O
Bent
Polar**

2. According to the Valence Bond Theory, what is the hybridization of the central atom in the molecules in problem 1?

- | | | | |
|-------------------|---|--------------------|---|
| a. PCl_3 | sp^3 | b. CHCl_3 | sp^3 |
| c. CO_2 | sp | d. TeCl_4 | dsp^3 |
| e. OF_2 | sp^3 | f. SF_6 | d^2sp^3 |
| g. BrF_5 | d^2sp^3 | h. SeO_2 | sp^2 |

3. How many sigma and pi bonds does the central atom of each molecule in problem 1 form?

- | | | | |
|-------------------|------------|--------------------|------------|
| a. PCl_3 | 3,0 | b. CHCl_3 | 4,0 |
| c. CO_2 | 2,2 | d. TeCl_4 | 4,0 |
| e. OF_2 | 2,0 | f. SF_6 | 6,0 |
| g. BrF_5 | 5,0 | h. SeO_2 | 2,1 |

4. Which of the following repulsions is the strongest?

- Lone pair—Lone pair**
- Bonding pair—Lone pair
- Bonding pair—Bonding pair

5. **True** or False. In order to have a delocalized bond a molecule must have a multiple bond.

Resonance requires at least one single and one multiple bond

6. True or **False**. The probability of finding an electron in pi antibonding orbital is highest between the two atoms.

7. There are _____ sigma and _____ pi bonds in the $\text{H}-\text{C}\equiv\text{C}-\text{H}$ molecule.

- 3, 2**
- 3, 4
- 4, 3
- 2, 3
- 5, 0

8. What is the hybridization of S in dihydrogen sulfide?

sp^3

9. Sulfur dioxide has how many pi bonds on the sulfur?

One

10. What is the hybridization of S in sulfur tetrafluoride?

dsp^3

11. How many sigma bonds are there on one of the N of Nitrogen gas?

One

12. What is the hybridization of N in nitrogen triiodide?

sp^3

13. NO_3^{-1} contains _____ sigma bonds and _____ pi bonds.
- 1, 3
 - 3, 0
 - 3, 3
 - 3, 1**
 - 0, 3
14. What is the molecular geometry of AsCl_3 ?
- trigonal pyramidal**
 - T-shaped
 - trigonal planar
 - tetrahedral
15. Which molecule contains a triple bond?
- F_2
 - H_2CO
 - HCN**
 - O_3
16. Which of the following molecules contains polar bonds but is nonpolar?
- SO_2
 - F_2
 - OF_2
 - NF_3
 - CF_4**
17. Of the following elements, which has the highest electronegativity?
- As
 - S**
 - P
 - Sc
18. Covalent bonding is a
- gain of electrons
 - sharing of electrons**
 - loss of electrons
 - transfer of electrons
19. Which one of the following is expected to exhibit resonance?
- NO_2^-**
 - NH_4^+
 - HCN
 - CO_2
20. What is the molecular geometry of IF_5 ?
- square pyramidal**

- b. trigonal bipyramidal
- c. seesaw
- d. octahedral

21. Based on the VSEPR theory, which should have the smallest XAX bond angle?

- a. A single bonded to Four X
- b. A double bonded to Two X ($X=A=X$)
- c. A single bonded to Three X, one lone pair electrons on A
- d. A single bonded to Two X, two lone pairs electrons on A**

22. Which bond should have the longest length?

- a. single bond**
- b. double bond
- c. triple bond
- d. all have the same length

23. Which molecular orbitals are found along the axis connecting two atoms outside the atomic centers?

- a. sigma bonding molecular orbitals
- b. pi bonding molecular orbitals
- c. sigma antibonding molecular orbitals**
- d. pi antibonding molecular orbitals