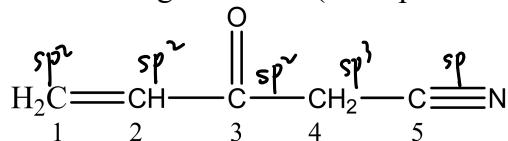


## Chapter 9 Homework

**Part A Multiple choice** (Select the one that is best in each case. 1 point/question)

- E 1. Consider the following molecule. (Lone pairs are not drawn in.)



Specify the hybridization of each carbon atom (in numeric order: C-1 C-2 C-3 C-4 C-5).

- A)  $sp^2$   $sp^2$   $sp^3$   $sp^3$   $sp^3$   
 B)  $sp^2$   $sp^2$   $sp^3$   $sp^3$   $sp$   
 C)  $sp$   $sp$   $sp$   $sp^2$   $sp$   
 D)  $sp^2$   $sp^2$   $sp^2$   $sp^3$   $sp^3$   
 E)  $sp^2$   $sp^2$   $sp^2$   $sp^3$   $sp$

- B 2. The molecule  $AX_3$ , in which A is the central atom, is ~~polar~~ and obeys the octet rule; therefore,

- A) A has two lone pairs.  
 B) A has one lone pair.  
 C) A has no lone pairs.  
 D) A has four bonding pairs.  
 E) A has three lone pairs.

- C 3. Which of the following has the shortest N—O bond?

- A)  $\text{NO}_2^-$       B)  $\text{N}_2$       C)  $\text{NO}^+$       D)  $\text{NO}_3^-$       E) none of these

- E 4. Which statement about the thiocyanate ion,  $\text{NCS}^-$ , is true?

- A) ~~Only~~ ~~one~~ correct resonance structure can be drawn.  
 B) Its Lewis structure contains ~~an~~ unpaired electron.  
 C) Its shape is ~~not~~ like that of  $\text{H}_2\text{O}$ .  
 D) There are ~~more~~ than two  $\sigma$  bonds in the ion.  
 E) none of these

- B 5. If four orbitals on one atom overlap four orbitals on a second atom, how many ~~molecular orbitals~~ will form?

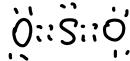
- A) 1      B) 8      C) 4      D) 16      E) none of these

- C 6. Which of the following statements is *false*?

- A) Paramagnetic molecules are attracted toward a magnetic field.  
 B) Paramagnetism cannot be deduced from the Lewis structure of a molecule alone.  
 C) Atoms or molecules with an even number of electrons are diamagnetic.  
 D)  $\text{N}_2$  molecules are diamagnetic.  
 E) Atoms or molecules with an odd number of electrons are paramagnetic.

- D 7. Which molecule is polar?

- A)  $\text{C}_2\text{H}_4$       B)  $\text{CS}_2$       C)  $\text{C}_6\text{H}_6$       D)  $\text{SO}_2$       E)  $\text{CF}_4$

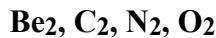


- D 8. The  $\pi$  bond in ethylene,  $\text{H}_2\text{C}=\text{CH}_2$ , results from the overlap of \_\_\_\_\_.

- A)  $sp^3$  hybrid orbitals  
 B)  $s$  atomic orbitals  
 C)  $sp$  hybrid orbitals  
 D)  $sp^2$  hybrid orbitals  
 E)  $p$  atomic orbitals

## Chapter 9 Homework

A. For how many of the following does the bond order decrease if you add one electron to the neutral molecule?



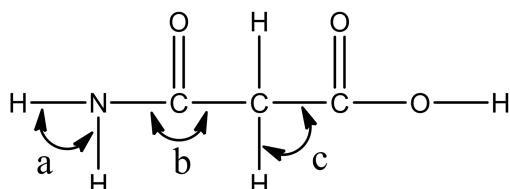
- A) 2      B) 1      C) 3      D) 0      E) 4

A. 10. What hybrid orbitals of sulfur are involved in the bonding in sulfur trioxide?

- A)  $sp^2$       B)  $sp^2d$       C)  $sp^3$       D)  $sp^3d^2$       E)  $sp$

$sp^3$

D. 11. The bond angles marked a, b, and c in the molecule below are about \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_, respectively. (Lone pairs are not drawn in.)



- A)  $90^\circ, 90^\circ, 90^\circ$   
~~B~~ C)  $120^\circ, 120^\circ, 90^\circ$   
~~C~~ D)  $120^\circ, 120^\circ, 109.5^\circ$   
D)  $109.5^\circ, 120^\circ, 109.5^\circ$   
E)  $109.5^\circ, 90^\circ, 120^\circ$

B. 12. For molecules of the general formula AB<sub>n</sub>, n can be greater than four \_\_\_\_\_.

- A) for any element A  
B) only when A is an element from period 3 and below in the periodic table  
C) only when A is boron or beryllium  
D) only when A is carbon  
E) only when A is Xe

E. 13. A typical triple bond \_\_\_\_\_.

- A) consists of three shared electrons  
B) consists of two  $\sigma$  bonds and one  $\pi$  bond  
C) consists of six shared electron pairs  
D) is longer than a single bond  
E) consists of one  $\sigma$  bond and two  $\pi$  bonds

E. 14. The more effectively two atomic orbitals overlap, \_\_\_\_\_.

- A) the more bonding MOs will be produced by the combination  
B) the higher will be the energy of the resulting bonding MO and the lower will be the energy of the resulting antibonding MO  
C) the higher will be the energies of both bonding and antibonding MOs that result  
D) the fewer antibonding MOs will be produced by the combination  
~~E~~ E) the lower will be the energy of the resulting bonding MO and the higher will be the energy of the resulting antibonding MO

B. 15. The hybridization of orbitals on the central atom in a molecule is  $sp$ . The electron-domain geometry around this central atom is \_\_\_\_\_.

- A) octahedral  
B) linear  
C) trigonal planar  
D) trigonal bipyramidal  
E) tetrahedral

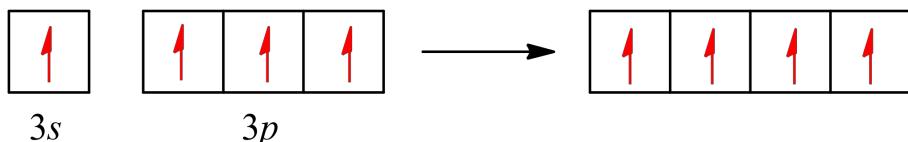
## Chapter 9 Homework

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### Part B Short questions (15 points)

16. (7 points) (a) Explain why  $\text{BrF}_4^-$  is square planar, whereas  $\text{BF}_4^-$  is tetrahedral.  
(b) How would you expect the H—X—H bond angle to vary in the series  $\text{H}_2\text{O}$ ,  $\text{H}_2\text{S}$ ,  $\text{H}_2\text{Se}$ ? Explain. (Hint: The size of an electron pair domain depends in part on the electronegativity of the central atom.)

17. (2 points) The orbital diagram that follows presents the final step in the formation of hybrid orbitals by a silicon atom.



- (a) Which of the following best describes what took place before the step pictured in the diagram: (i) Two  $3p$  electrons became unpaired, (ii) An electron was promoted from the  $2p$  orbital to the  $3s$  orbital, or (iii) An electron was promoted from the  $3s$  orbital to the  $3p$  orbital?  
(b) What type of hybrid orbital is produced in this hybridization?

18. (6 points) Explain the following: (a)  $\text{B}_2$  is paramagnetic, which is consistent with the  $\pi_{2p}$  MOs being lower in energy than the  $\sigma_{2p}$  MO. (b) The  $\text{O}_2^{2+}$  ion has a stronger O—O bond than  $\text{O}_2$  itself.

## Chapter 9 Homework Answer Sheet

Name: 陈伟

Student ID: 12311410

Instructor:

Score:

### Part A Multiple choice (15 points)

1-5 E B C E B.

6-10 C D D A A.

11-15 D B E E B.

### Part B Short questions (15 points)

16. (7 points) (a) Explain why  $\text{BrF}_4^-$  is square planar, whereas  $\text{BF}_4^-$  is tetrahedral.

(b) How would you expect the H—X—H bond angle to vary in the series  $\text{H}_2\text{O}$ ,  $\text{H}_2\text{S}$ ,  $\text{H}_2\text{Se}$ ? Explain. (Hint: The size of an electron pair domain depends in part on the electronegativity of the central atom.)

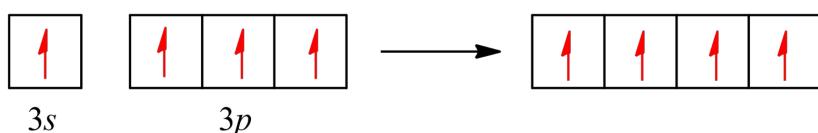
(a).  $\text{BrF}_4^-$ : 4 Br-F bonds + 2 lone pairs  $\Rightarrow$  octahedral.

$\text{BF}_4^-$ : 4 bonding domain, no lone pair  $\Rightarrow$  tetrahedral.

(b).  $\text{H}_2\text{O} > \text{H}_2\text{S} > \text{H}_2\text{Se}$ .

$\xrightarrow{\text{electronegativity } \downarrow}$   
atom gets larger. }  $\Rightarrow$  X-H is less tight  
the lone-pair/bond-pair repulsions shrink.  
 $\Rightarrow$  H-X-H angle drops.

17. (2 points) The orbital diagram that follows presents the final step in the formation of hybrid orbitals by a silicon atom.



(a) Which of the following best describes what took place before the step pictured in the diagram: (i) Two 3p electrons became unpaired, (ii) An electron was promoted from the 2p orbital to the 3s orbital, or (iii) An electron was promoted from the 3s orbital to the 3p orbital?

(b) What type of hybrid orbital is produced in this hybridization?

(a). (iii). Since the result is 4 unpaired electrons.

(b).  $\text{sp}^3$ .

18. (6 points) Explain the following: (a)  $\text{B}_2$  is paramagnetic, which is consistent with the  $\pi_{2p}$  MOs being lower in energy than the  $\sigma_{2p}$  MO. (b) The  $\text{O}_2^{2+}$  ion has a stronger O—O bond than  $\text{O}_2$  itself.

(a).  $\text{B}_2$  has 10 electrons.

After filling  $\sigma_{1s}$ ,  $\sigma_{1s}^*$ ,  $\sigma_{2s}$ ,  $\sigma_{2s}^*$ , we still has 2 electrons.

By Hund's rule they will occupy 2  $\pi_p$  orbitals.

$\Rightarrow$  these two unpaired electrons make  $O_2$  paramagnetic.

(b). bond order:  $O_2$ :  $\frac{1}{2}(8-4) = 2$ .

$O_2^{2+}$ :  $\frac{1}{2}(8-2) = 3$ .

$\Rightarrow O_2^{2+}$  has a higher bond order.