

# Workbook



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# More Aspects of Chemical Bonding

## Valence bond VB method

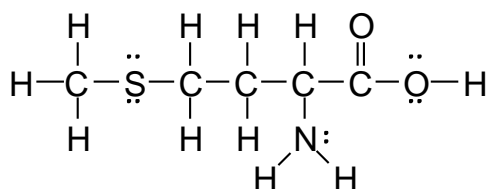
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### Questions

1) Draw the valence shell orbital diagram (hybridization of pure atomic orbitals, to hybrid atomic orbitals) of the central atom in the following molecules:

- a.  $\text{CCl}_4$
- b.  $\text{COH}_2$
- c.  $\text{N}_2$

2) What are the hybridizations ( $sp$ ,  $sp^2$ , etc.) of the central atoms in the following molecule:



3) For the following molecules,

- a. Predict the electron group geometry by VSEPR theory.
- b. Determine the hybridization of the central atoms:
  - a)  $\text{S}_8$
  - b)  $\text{SO}_2$
  - c)  $\text{H}_2\text{SO}_4$

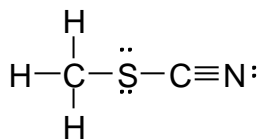
4) Determine the hybridization of the following molecules:

- a.  $\text{PCl}_5$
- b.  $\text{COCl}_2$
- c.  $\text{SF}_6$

## General Chemistry Workbook

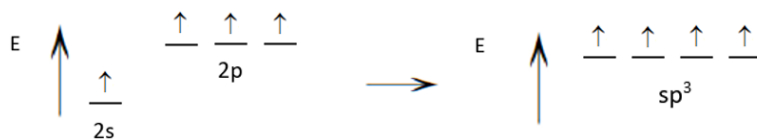
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- 5) For the following molecule,
- Predict the electron group geometry by VSEPR theory.
  - Determine the hybridization of the central atoms.
  - Identify the orbitals of the central and terminal atoms that are involved, in orbital overlap.

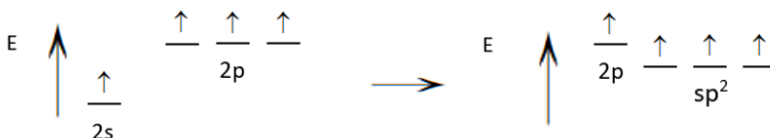


## Answer Key

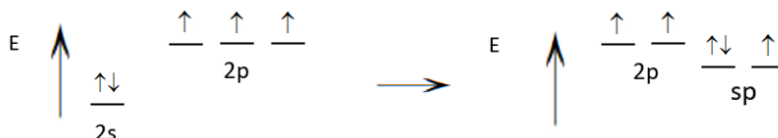
1) a.



b.



c.



2) C<sub>1-4</sub>: sp<sup>3</sup>

S: sp<sup>3</sup>

C<sub>5</sub>: sp<sup>2</sup>

O<sub>1</sub>: sp<sup>3</sup>

N: sp<sup>3</sup>

3) S<sub>8</sub>:

S: tetrahedral, sp<sup>3</sup>

SO<sub>2</sub>:

S: trigonal planar, sp<sup>2</sup>

H<sub>2</sub>SO<sub>4</sub>:

S: tetrahedral, sp<sup>3</sup>

O: tetrahedral, sp<sup>3</sup>

- 4) a.  $sp^3d$   
b.  $sp^2$   
c.  $sp^3d^2$
- 5) C<sub>1</sub>: tetrahedral,  $sp^3$   
S: tetrahedral,  $sp^3$   
C<sub>2</sub>: linear,  $sp$   
Orbital overlap:  
H 1s – C<sub>1</sub>  $sp^3$   
C<sub>1</sub>  $sp^3$  – S  $sp^3$   
S  $sp^3$  – C<sub>2</sub>  $sp$   
C<sub>2</sub>  $sp$  – N  $sp$

### Molecular orbital MO theory

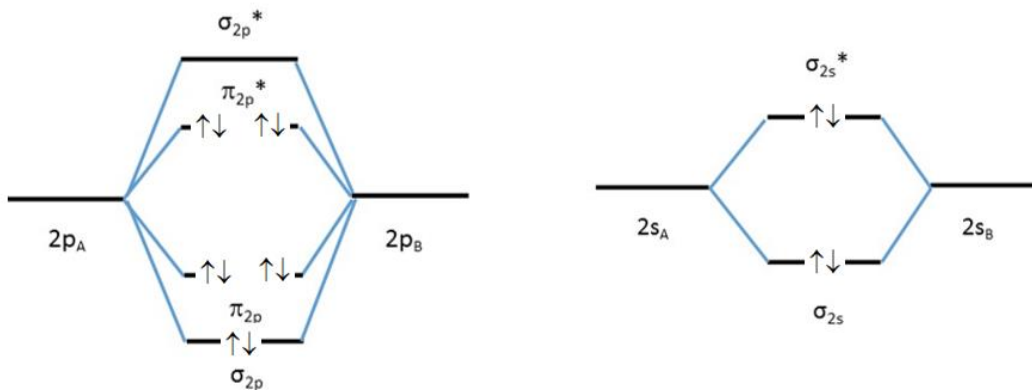
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#### Questions

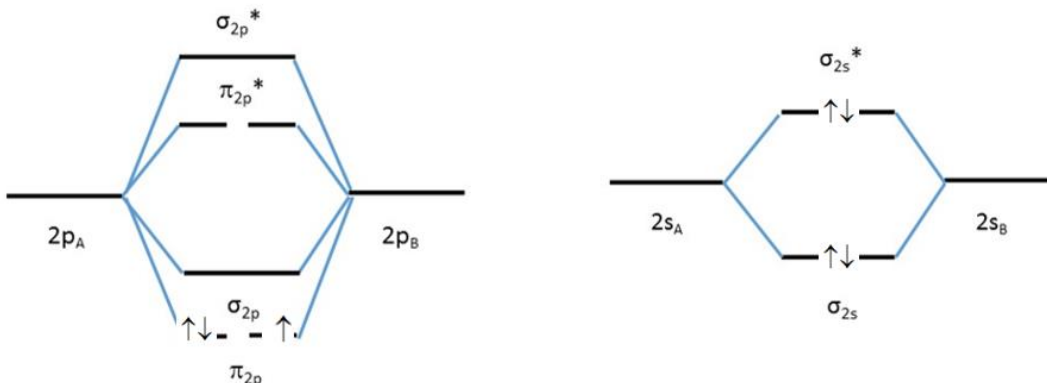
- 1) Sketch the molecular orbital diagrams for the following species:
  - a.  $F_2$
  - b.  $C_2^+$
  
- 2)
  - a. Calculate the bond order of  $O_2$  using the molecular orbital diagram.
  - b. Determine the number of unpaired electrons.
  - c. Is the molecule paramagnetic or diamagnetic?
  
- 3) Calculate the bond order of the following ions and determine if they are stable, using the molecular orbital diagram:
  - a.  $F_2^{2+}$
  - b.  $C_2^{2-}$
  
- 4) Explain why the oxidation of  $O_2$  decreases the bond distance whereas the oxidation, of  $N_2$  increases the bond distance.
  
- 5) Sketch a molecular orbital diagram for  $H_2^-$ .  
Does the extra electron make the H-H bond stronger compared to  $H_2$ ?  
Explain your answer.

## Answer Key

1) a.



b.



2) a. 2

b. 2

c. paramagnetic

3) a. bond order = 2, stable

b. bond order = 3, stable

4) When  $O_2$  is oxidized, the bond order increases.

When  $N_2$  is oxidized, the bond order decreases.

Bond order and bond distance are inversely proportional.

Therefore, an increase in bond order means a decrease in bond distance and vice versa.



## General Chemistry Workbook

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5) Bond order of  $\text{H}_2^- = 0.5$

Bond order of  $\text{H}_2 = 1$

The extra electron makes the H-H bond weaker because the bond order decreases, as a result of the extra electron.

