1. Specify the electron-pair and molecular geometry for each of the following. Describe the hybrid orbital set used by the underlined atom in each molecule or ion?

   (a) $\text{CSe}_2$
   \[ \text{sp} \]
   \[ \text{sp}^2 \]
   \[ \text{sp}^3 \]
   \[ \text{sp}^3d \]

   (b) $\text{SO}_2$
   \[ \text{sp} \]
   \[ \text{sp}^2 \]
   \[ \text{sp}^3 \]
   \[ \text{sp}^3d \]

   (c) $\text{CH}_2\text{O}$
   \[ \text{sp} \]
   \[ \text{sp}^2 \]
   \[ \text{sp}^3 \]
   \[ \text{sp}^3d \]

   (d) $\text{NH}_4^+$
   \[ \text{sp} \]
   \[ \text{sp}^2 \]
   \[ \text{sp}^3 \]
   \[ \text{sp}^3d \]

2. Describe the hybrid orbital set used by each of the indicated atoms in the molecules listed below. (Type your answer using the format sp2 for sp$^2$.)

   (a) left carbon atom in dimethyl ether, $\text{CH}_3\text{OCH}_3$
   
   oxygen atom in dimethyl ether

   (b) center carbon atom in propene
Give the hybrid orbital set used by each of the underlined atoms in the following molecules. (Type your answer using the format \(sp^2\) for \(sp^2\).)

(a)
\[
\begin{array}{c}
\text{N} \\
\text{C}
\end{array}
\]

(b)
\[
\begin{array}{c}
\text{C of CH}_3 \\
\text{C of C=C} \\
\text{C of C=O}
\end{array}
\]

(c)
\[
\begin{array}{c}
\text{C of C=C} \\
\text{C of C=N}
\end{array}
\]
Calcium carbide, CaC₂, contains the acetylide ion, C₂²⁻.

(a) How many net \( \sigma \) and \( \pi \) bonds does the ion have?
\[
\sigma = \\
\pi = 
\]
(b) What is the carbon-carbon bond order?
(c) How has the bond order changed on adding electrons to C₂ to obtain C₂²⁻?
- yes
- no
(d) Is the C₂²⁻ ion paramagnetic?
- The bond order increases by one going from C₂ to C₂⁻.
- The bond order decreases by one going from C₂ to C₂⁻.

Oxygen, O₂, can acquire one or two electrons to give O₂⁻ (superoxide ion) or O₂²⁻ (peroxide ion). Write the electron configuration for the ions in molecular orbital terms (Do this on paper. Your instructor may ask you to turn in this work.). Compare them with the O₂ molecule on the following bases.

<table>
<thead>
<tr>
<th></th>
<th>O₂</th>
<th>O₂⁻</th>
<th>O₂²⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) magnetic character</td>
<td>---Select---</td>
<td>---Select---</td>
<td>---Select---</td>
</tr>
<tr>
<td>(b) net number of ( \pi ) bonds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) bond order</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(d) Which of the following has the shortest bond length. O₂, O₂⁻, O₂²⁻?
- O₂
- O₂⁻
- O₂²⁻
Acrolein, a component of photochemical smog, has a pungent odor and irritates eyes and mucous membranes.

(a) What are the hybridizations of carbon atoms 1 and 2?
- sp^2
- sp^3d^2
- sp^3d
- sp^3

(b) What are the approximate values of angles A, B, and C?

- angle A
  - 109°
  - 120°
  - 180°
- angle B
  - 109°
  - 120°
  - 180°
- angle C
  - 109°
  - 120°
  - 180°

(c) Is cis-trans isomerism possible here?
Lactic acid is a natural compound found in sour milk.

(a) How many \( \pi \) bonds occur in lactic acid? 
How many \( \sigma \) bonds occur in lactic acid? 

(b) Describe the hybridization of each atom 1 through 3.

C(1)
- \( sp^2 \)
- \( sp^3 \)
- \( sp^3d \)
- \( sp^3d^2 \)

C(2)
- \( sp \)
- \( sp^2 \)
- \( sp^3 \)
- \( sp^3d \)

O(3)
- \( sp^2 \)
- \( sp^3 \)
- \( sp^3d \)
- \( sp^3d^2 \)

(c) Which CO bond is the shortest in the molecule?
- C-O bond
- C=O

Which CO bond is the strongest in the molecule?
- C-O bond
- C=O

(d) What are the approximate values of the bond angles A, B, and C?

A = 
B = 
C =

Which of the following molecules or molecule ions should be paramagnetic? What is the highest occupied molecular orbital (HOMO) in each one? Assume the molecular orbital diagram in Figure 10.22 applies to all of them. (Type your answer using the format \( \sigma^2p \) for \( \sigma^2p \) or \( \pi 2p \) for \( \pi 2p \).)
Menthol is used in soaps, perfumes, and foods. It is present in the common herb mint, and it can be prepared from turpentine.

(a) What are the hybridizations used by the C atoms in the molecule?
- All of the C atoms are \( sp \) hybridized.
- All of the C atoms are \( sp^3 \) hybridized.
- Some of the C atoms are \( sp^2 \) hybridized and some are \( sp^3 \) hybridized.
- All of the C atoms are \( sp^2 \) hybridized.

(b) What is the approximate C-O-H bond angle?
- 60°
- 90°
- 109°
- 120°

(c) Is the molecule polar or nonpolar?
- nonpolar
- polar

(d) Is the six-member carbon ring planar or nonplanar?
- planar
- nonplanar

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