1. Which of the following are correct statements about the valence–shell electron–pair repulsion (VSEPR) model of bonding?

1. Electron pairs orient themselves to give the smallest angles possible.
2. Only bonding electron pairs are important in the VSEPR model.
3. Electron-pair geometry in all cases describes the spatial geometry of the atoms in the molecule.

A. 1 only
B. 2 only
C. 3 only
D. 1, 2, and 3
E. None of the above

2. Which of the following is non-planar?

A. SO₂
B. SO₃⁻
C. SO₄²⁻
D. NO₃⁻
E. BF₃

3. The number of bonding pairs of electrons, non-bonding pairs of electrons and molecular shape of the H₃O⁺ ion are

<table>
<thead>
<tr>
<th>Bonding Pairs</th>
<th>Non-bonding Pairs</th>
<th>Molecular Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 4</td>
<td>0</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>B. 3</td>
<td>1</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>C. 2</td>
<td>2</td>
<td>bent</td>
</tr>
<tr>
<td>D. 3</td>
<td>1</td>
<td>trigonal pyramidal</td>
</tr>
<tr>
<td>E. 3</td>
<td>0</td>
<td>trigonal planar</td>
</tr>
</tbody>
</table>
Among the following gaseous molecules

BeF$_2$  BF$_3$  CF$_4$  NF$_3$  OF$_2$

What is the correct trend in FMF bond angle?

<table>
<thead>
<tr>
<th>LARGEST</th>
<th>SMALLEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. BeF$_2$ &gt; BF$_3$ &gt; CF$_4$ &gt; NF$_3$ &gt; OF$_2$</td>
<td></td>
</tr>
<tr>
<td>B. BeF$_2$ = OF$_2$ &gt; CF$_4$ &gt; BF$_3$ = NF$_3$</td>
<td></td>
</tr>
<tr>
<td>C. BeF$_2$ = OF$_2$ &gt; BF$_3$ = NF$_3$ &gt; CF$_4$</td>
<td></td>
</tr>
<tr>
<td>D. BeF$_2$ &gt; BF$_3$ &gt; OF$_2$ &gt; NF$_3$ &gt; CF$_4$</td>
<td></td>
</tr>
<tr>
<td>E. CF$_4$ &gt; BF$_3$ = NF$_3$ &gt; BeF$_2$ = OF$_2$</td>
<td></td>
</tr>
</tbody>
</table>

Which of the following molecules has a trigonal planar structure?

1. CO$_3^{2-}$
2. SOCl$_2$
3. H$_3$O$^+$
4. SO$_3^{2-}$

A. 1 only
B. 1, 2 and 3
C. 1 and 3
D. 1, 3 and 4
E. 3 and 4

Which of the following molecules and ions possesses a tetrahedral molecular structure?

A. TeI$_4$
B. SeBr$_4$
C. XeCl$_4$
D. NH$_3$
E. AlF$_4^-$

The bond angles in H$_2$O$_2$ are approximately:

A. 90°
B. 105°
C. 109.5°
D. 120°
E. 180°
8. Identify which of the following bonds is(are) polar and which element in each is the more electronegative.

HCl  NO  Si₂

Now consider these five statements about your conclusions.

1. HCl is polar, with H the more electronegative.
2. HCl is polar, with the Cl the more electronegative.
3. NO is polar, with the N the more electronegative.
4. NO is polar, with O the more electronegative.
5. Si₂ is polar.

The correct statement(s) above is(are)

A. 2 only
B. 2 and 3 only
C. 2 and 4 only
D. 2, 3 and 5 only
E. 1 and 4 only

9. Consider the following molecules.

1. BF₃  2. NH₃  3. SOCl₂  4. SiF₄

Which of these should have a dipole moment?

A. 2 only
B. 2, 3 and 4 only
C. 1, 2 and 3 only
D. 1 and 4 only
E. 2 and 3 only

10. Which of the following molecules has the largest dipole moment?

A. XeF₂
B. XeF₄
C. PF₅
D. SF₄
E. SF₆
11. Which of the following benzene–like molecules do you expect to have the largest dipole moment?

A.  

B.  

C.  

D.  

E.  

12. Which of the following statements is true?

A. There are two \( \pi \) bonds in \( \text{H} \text{C} = \text{C} \text{H} \).

B. The H–N–H angle in \( \text{NH}_3 \) is slightly larger than the H–C–H angle in \( \text{CH}_4 \).

C. In \( \text{CO}_2 \), the carbon is \( \text{sp}^2 \) hybridized.

D. The molecule below possesses a dipole moment.

E. None of the above statements is true.
13. Which of the following is a correct set of electron–pair geometry, hybridization, and bond angle(s)?

<table>
<thead>
<tr>
<th>Geometry</th>
<th>Hybridization</th>
<th>Bond Angle(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. linear</td>
<td>$sp^2$</td>
<td>180°</td>
</tr>
<tr>
<td>B. trigonal planar</td>
<td>$sp^2$</td>
<td>120°</td>
</tr>
<tr>
<td>C. octahedral</td>
<td>$d^2sp^3$</td>
<td>60°</td>
</tr>
<tr>
<td>D. tetrahedral</td>
<td>$dsp^3$</td>
<td>109.5°</td>
</tr>
<tr>
<td>E. trigonal bipyramidal</td>
<td>$d^2sp^3$</td>
<td>120°, 90°</td>
</tr>
</tbody>
</table>

14. Of the following statements about delocalized bonds, which are true?

1. They occur in molecules with alternating single and double bonds.
2. They can be made from $sp^2$ hybrid $\sigma$ bonds.
3. They are most often found in bonds involving heavy atoms.
4. They can be made from $\pi$ bonds.
5. They rarely, if ever, involve bonds with fluorine.

A. 1, 4, and 5 only  
B. 4 and 5 only  
C. 1, 3, and 4 only  
D. 1, 2, and 3 only  
E. All of the above

15. Which of the following statements is incorrect?

A. Hybridization accounts for the experimental observation that all F–C–F bond angles in CF$_4$ are the same.
B. All C–C bond distances in benzene, C$_6$H$_6$, are the same.
C. The energy required to break a carbon-carbon triple bond is greater than that needed to break a carbon-carbon double bond.
D. The bonding in benzene, C$_6$H$_6$, includes 12 sigma ($\sigma$) bonds and 3 localized pi ($\pi$) bonds.
E. The $\pi$ electrons in NO$_3^-$ are delocalized.
16. The following molecule should be used

The hybridizations of C₁, C₂ and C₃ respectively are

A. sp³ sp³ sp²
B. sp³ sp sp³
C. sp³ sp³ sp³
D. dsp³ sp sp²
E. None of the above.

17. Borazine B₃N₃H₆ has been called inorganic benzene. What is the hybridization of the boron atoms?

A. sp₂
B. sp³
C. dsp³
D. sp⁴
E. dsp³