1. How much P is contained in 10.0 g of $\text{H}_3\text{PO}_4$?
   A. 1.25 g
   B. 3.16 g
   C. 3.33 g
   D. 6.46 g
   E. 8.23 g

2. Which of the following has the largest number of atoms?
   A. 0.2 moles of $\text{H}_2\text{SO}_4$
   B. 0.5 moles of $\text{HCl}$
   C. 2.0 g of $\text{H}_2$
   D. 6.0 g of $\text{O}_2$
   E. 8.0 g of $\text{H}_2\text{O}$

3. Which of the following molecular formulas could be associated with an alkyne?
   A. $\text{C}_{13}\text{H}_{28}$
   B. $\text{C}_{22}\text{H}_{44}$
   C. $\text{C}_8\text{H}_{16}$
   D. $\text{C}_{15}\text{H}_{28}$
   E. $\text{C}_{10}\text{H}_{22}$

4. The percent composition of C in a 0.1453 g of an unknown hydrocarbon is found to be 82.66% by mass. What is the empirical formula of the compound?
   A. $\text{CH}$
   B. $\text{C}_2\text{H}_3$
   C. $\text{CH}_2$
   D. $\text{C}_3\text{H}_5$
   E. $\text{CH}_3$

5. What functional groups are present in the molecule shown?
   1. alcohol
   2. aldehyde
   3. carboxylic acid
   4. ketone
   A. 1 only
   B. 1 and 4 only
   C. 3 only
   D. 2 only
   E. 2 and 4 only
6. What are the hybrid orbitals found on the central atoms in SiF₄, SF₄, and XeF₄?

<table>
<thead>
<tr>
<th></th>
<th>SiF₄</th>
<th>SF₄</th>
<th>XeF₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>sp³</td>
<td>sp³</td>
<td>sp³d²</td>
</tr>
<tr>
<td>B.</td>
<td>sp³d²</td>
<td>sp³d²</td>
<td>sp³d²</td>
</tr>
<tr>
<td>C.</td>
<td>sp³d²</td>
<td>sp³d²</td>
<td>sp³d²</td>
</tr>
<tr>
<td>D.</td>
<td>sp³</td>
<td>sp³d²</td>
<td>sp³d²</td>
</tr>
<tr>
<td>E.</td>
<td>sp³d²</td>
<td>sp³d²</td>
<td>sp³d²</td>
</tr>
</tbody>
</table>

7. What are the correct molecular geometries for the regions of the molecule shown below.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>trigonal pyramid</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>B.</td>
<td>trigonal planar</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>C.</td>
<td>trigonal planar</td>
<td>trigonal planar</td>
</tr>
<tr>
<td>D.</td>
<td>trigonal pyramid</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>E.</td>
<td>tetrahedral</td>
<td>tetrahedral</td>
</tr>
</tbody>
</table>

8. Which one of these molecules has the most π bonds?

9. Consider the generic formula AB₄. Using the VSEPR model as discussed in lecture, how many different molecular geometries are possible for this compound?

A. 1
B. 2
C. 3
D. 4
E. 5
10. Which of these molecules exhibits the greatest dipole moment?

A. \( \text{H}_2 \)
B. \( \text{HF} \)
C. \( \text{HCl} \)
D. \( \text{HBr} \)
E. \( \text{HI} \)

11. Which one of these drawings represents one or more delocalized \( \pi \) bonds?

I
II
III
IV

A. I only
B. II only
C. III only
D. I and II
E. III and IV

12. Which of the following molecules are structural isomers of each other?

Which one of these drawings represents one or more delocalized \( \pi \) bonds?

A. 2 and 3 only
B. 1 and 4 only
C. 1 and 2 only
D. 1, 2 and 4
E. There are no structural isomers present

13. Which of the molecules below does not have the empirical formula \( \text{C}_3\text{H}_6\text{O} \)?

I
II
III
IV

A. I only
B. II only
C. III only
D. IV only
E. both III and IV
14. A compound made up of only chlorine and fluorine contains 61.65% fluorine by mass. Assuming that the empirical formula equals the molecular formula of this compound, what is the electron domain geometry of the central atom of this compound?

A. linear  
B. trigonal planar  
C. tetrahedral  
D. trigonal bipyramidal  
E. octahedral

15. The approximate values for the indicated bond angles 1, 2, and 3 in the following molecule are:

\[ \begin{array}{cccc} 
\text{Angle 1} & \text{Angle 2} & \text{Angle 3} \\
\text{A.}<120^\circ & <109.5^\circ & 109.5^\circ \\
\text{B.}>120^\circ & >109.5^\circ & 109.5^\circ \\
\text{C.}>120^\circ & <109.5^\circ & 109.5^\circ \\
\text{D.}<109.5^\circ & <109.5^\circ & >109.5^\circ \\
\text{E.}<90^\circ & <109.5^\circ & 109.5^\circ \\
\end{array} \]

16. Put the following three molecules in order of increasing $F-X-F$ bond angle, where $X$ is the central atom.

<table>
<thead>
<tr>
<th>$CF_4$</th>
<th>$OF_2$</th>
<th>$NF_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. $OF_2 &lt; NF_3 &lt; CF_4$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. $CF_4 &lt; OF_2 &lt; NF_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. $CF_4 &lt; NF_3 &lt; OF_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. $OF_2 &lt; CF_4 &lt; NF_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. $NF_3 &lt; CF_4 &lt; OF_2$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. Which of the following species is not planar?

A. $SO_3$  
B. $SF_4$  
C. $BF_3$  
D. $ICl_4$  
E. $C_2H_4$

18. Three monosulfur fluorides are known to exist, $SF_2$, $SF_4$ and $SF_6$. Which of these are polar?

A. $SF_2$ only  
B. $SF_4$ only  
C. $SF_2$ and $SF_4$  
D. $SF_4$ and $SF_6$  
E. $SF_2$, $SF_4$ and $SF_6$
19. What are the important intermolecular forces between molecules of phenol (shown below) in the liquid state?

i. Dispersion forces  
ii. Dipole-dipole interaction  
iii. Hydrogen bonding

A. i only  
B. ii only  
C. iii only  
D. ii and iii  
E. i, ii and iii

20. Put these molecules in order of increasing melting point.

\[
\begin{align*}
\text{I} & \quad \text{II} & \quad \text{III} \\
\text{CH}_3 & \text{CH}_3 & \text{CH}_3 \\
\text{CH}_3 & \text{CH}_3 & \text{CH}_3 \\
\text{CH}_3 & \text{CH}_3 & \text{CH}_3 \\
\end{align*}
\]

A. I < II < III  
B. I < III < II  
C. II < III < I  
D. III < I < II  
E. III < II < I

21. Indigo is the dye used in coloring blue jeans. The term navy blue is derived from the use of indigo to dye British naval uniforms in the eighteenth century. The carbon backbone structure of the indigo molecule is shown below. Which statement about the carbon atoms in this molecule is true??

A. All of the carbon atoms are sp\(^3\) hybridized.  
B. All of the carbon atoms are sp\(^2\) hybridized.  
C. All of the carbon atoms are sp hybridized.  
D. Some of the carbon atoms are sp\(^2\) hybridized and some are sp\(^3\) hybridized.  
E. Some of the carbon atoms are sp hybridized and some are sp\(^3\) hybridized.
22. Which type of intermolecular force accounts for the fact that acetone boils at 56 °C, whereas 2-methylpropane boils at −12 °C?

A. Dispersion  
B. Hydrogen bonding  
C. Dipole-dipole  
D. Dipole-induced dipole  
E. Ion-dipole

23. Which statement about the following molecule is false?

A. The molecule shown above has 5 σ and 2 π bonds.  
B. The F–C–H bond is approximately (but less than) 120°.  
C. The hybridization of both of the carbon atoms is sp².  
D. The molecule shown above is polar.  
E. The structure shown below is a geometrical isomer of the molecule above.

24. The molecule below is cis 2-pentene.

Which one of these molecules is a geometric isomer of cis 2-pentene?

A  
B  
C  
D  
E

25. Consider the molecule shown to the right. Elemental analysis shows this molecule to be 41.7% C by mass. Which of the following elements could be the identity of X?

A. O  
B. Br  
C. S  
D. Cl  
E. P
26. A scientist working in a crime lab analyzes an unknown compound from a crime scene. The compound is found to be 32.0% C, 6.7% H, and 18.7% N by mass. Which of the following compounds could this unknown be?

- Ethanol
- Nicotine
- Amino Acid (Protein)
- Methamphetamine
- None of these

![Ethanol](ethanol.png)  ![Nicotine](nicotine.png)  ![Amino Acid (Protein)](amino_acid.png)  ![Methamphetamine](methamphetamine.png)

A. Ethanol  
B. Nicotine  
C. Amino Acid  
D. Methamphetamine  
E. None of these

27. Combustion analysis was performed on 1.50g of a compound containing C, H and N to yield 3.21g of carbon dioxide and 0.981g of water. What is the empirical formula of this compound?

A. CHN  
B. CH₂N  
C. C₂H₂N  
D. C₂H₃N  
E. C₃H₂N₂

28. Which one of these molecules will react readily with Br₂ via addition reaction?

- I only  
- II only  
- III only  
- both III and IV  
- II, III, and IV

![Molecules](molecules.png)

A. I only  
B. II only  
C. III only  
D. both III and IV  
E. II, III, and IV

END OF EXAM
CHEMISTRY 110 EXAM 2
OCTOBER 10, 2011
Answer Key

FORM A

1. B
2. C
3. D
4. D
5. B
6. D
7. A
8. D
9. C
10. B
11. Full credit for all choices
12. D
13. D
14. D
15. C
16. A
17. B
18. C
19. E
20. E
21. A
22. C
23. A
24. E
25. B
26. C
27. D
28. E