*1. (5) Draw a *constitutional isomer* of the structure shown.

\[ \text{Cl} \quad \text{Cl} \quad \text{Cl} \quad \text{Cl} \quad \text{Cl} \quad \text{Cl} \]

*2. (8) For the formula shown below, draw two *constitutional isomers*. Use only line structures (aka line forms).

\[ \text{a) } \text{C}_4\text{H}_6\text{O} \]

\[ \text{b) } \text{O} = \text{C} - \text{O} \]

\[ \text{c) } \text{O} = \text{C} - \text{C} - \text{OH} \]

*3. (4) Circle *any* of the following species that would be considered to be a strong Lewis Acid?

\[ \begin{array}{llll}
\text{H} \cdot \cdot \cdot \text{P} - \text{CH}_3 & \text{H} \cdot \cdot \cdot \text{C} - \text{H} & \text{II} & \text{III} \\
\text{H} & \text{CH}_2 & & \text{Br} \cdot \cdot \cdot - \\
\text{I} & \text{II} & \text{III} & \text{IV}
\end{array} \]

*4. (12) Show the partial (use \( \delta^+ \) or \( \delta^- \)) or real charges (use + or -) that would be present in *each* of the following if a bond was formed between the pairs of atoms shown.

\[ \begin{array}{llll}
\text{a) } \text{P} \delta^+, \text{O} \delta^- & \text{b) } \text{C} -, \text{Mg}^+ & \text{c) } \text{F} \delta-, \text{S} \delta^+ & \text{d) } \text{Na}^+, \text{N} -
\end{array} \]

*5. (12) Fill in any non-bonding valence electrons (lone pairs) missing from the following structures:

\[ \begin{array}{llll}
\text{a) } & \text{b) } & \text{c) } \\
\text{H}_2\text{C} = \text{C} = \text{NH} & & \\
\end{array} \]
6. (9) Provide a correct systematic (IUPAC) name for the following molecule. In addition, indicate how many primary, secondary and tertiary carbons are present in the molecule.

(CH₃)₃CCH(CH₂CH₃)CH(CH₃)CH(CH₃)CH(CH₃)₂

3-ethyl-2,2,4,5,6-pentamethylheptane

8 primary carbons
1 secondary carbon
4 tertiary carbons
1 quartenary carbon

7. (10) In the following molecules, state what the hybridization is of the four indicated atoms.

a) sp³

b) sp³

c) sp³

8. (4) What is the shape of the molecule shown in question 7a above? Choices: tetrahedral; trigonal planar; linear.

Tetrahedral

9. (3) True or False? A N atom with 4 different things attached will always be sp³.

True

10. (3) True or False? Hydrogen bonds are stronger than Van Der Waal's forces.

True

11. (3) True or False? In general, the greater the number of electronegative elements present in a molecule the higher the boiling point.

True

12. (12) Show the formal charge of the appropriate atoms in each of the following molecules or ions. You need not show your working.

a) B

b) C

c) N

13. (3) Which of the following isolated elements has 3 valence electrons?

a) Oxygen, atomic number 8
b) Nitrogen, atomic number 7
c) Carbon, atomic number 6
d) Boron, atomic number 5
*14. (13) Name the following molecules using any acceptable method.

a) 4-ethyl-3-isopropyl-1,1-dimethylcycloheptane

b) 2,3,8-trimethyl-5-(1-methylpropyl)nonane

1-ethyl-2-isopropyl-4,4-dimethylcycloheptane - also OK

*15. (3.5) Which side of this equilibrium is favored?

\[ \text{CH}_3\text{OH} + \text{LiNH}_2 \rightleftharpoons \text{LiOCH}_3 + \text{NH}_3 \]

\[ \text{pKa} = 16.5 \quad \text{pKa} = 35 \]

(A) left  (B) right

*16. (7.5) Circle any of the molecules shown below that will form hydrogen bonds to other molecules of themselves.

a) 

b) 

c) 

*17. (9) In each of the following pairs, state whether the compounds shown are constitutional isomers, identical or completely different.

a) completely different

b) identical

c) constitutional isomers
18. (8) In the molecule shown below, for each bond indicated with an arrow (2 examples), state the types of orbital, from each atom, which were used in making the bond.

\[ \text{H}_2\text{C} = \text{C} = \text{N} = \text{Cl} \]

*18. (8) In the molecule shown below, for each bond indicated with an arrow (2 examples), state the types of orbital, from each atom, which were used in making the bond.

![Molecule diagram]

sigma bond only \( \text{sp}^2 \) and \( \text{sp}^3 \)

*19. (4) Which of the following is closest to the P-F bond angle in PF\(_3\)?

a) 180\(^\circ\)  

b) 120\(^\circ\)  

c) 109.5\(^\circ\)  

d) 90\(^\circ\)

*19. (4) Which of the following is closest to the P-F bond angle in PF\(_3\)?

![Molecule diagram]

**19. (4) Which of the following is closest to the P-F bond angle in PF\(_3\)?**

a) 180\(^\circ\)  

b) 120\(^\circ\)  

c) 109.5\(^\circ\)  

d) 90\(^\circ\)

*20. (4) Put a check beside any of the answers below which apply to the alkane conformation shown.

![Molecule diagram]

Gauche
Anti
Staggered
Eclipsed

*20. (4) Put a check beside any of the answers below which apply to the alkane conformation shown.

![Molecule diagram]

Gauche
Anti
Staggered
Eclipsed

*21. (5) As the molecule shown in question 20 rotates it experiences what types of strain. Choose one or more from the following: angle; torsional; steric; bacterial.

*21. (5) As the molecule shown in question 20 rotates it experiences what types of strain. Choose one or more from the following: angle; torsional; steric; bacterial.

*22. (8) Circle the molecule in each of the following pairs, which best fits the given description.

a) CH\(_4\) and H\(_2\)O :  

stronger Lewis Acid

b) H\(_3\)C – NH\(_2\) and Na\(^+\) : OCH\(_3\) :  

stronger Lewis Base