*1. (8) For both of the following molecules shown, draw one constitutional isomer.

*2. (5) Indicate the number of hydrogens bonded to each carbon atom in the following compound and provide the molecular formula for the molecule.

*3. (18) List the charge (if any) and hybridization for the central atom in each of the following species as drawn. State also whether the bond arrangement around that atom is linear, trigonal planar or tetrahedral.

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

*5. (3) Which has the weaker conjugate base, water (pKa = 16) or methane (pKa = 55)?

   Water because it is a stronger acid

*6. (2.5) True or False? Lewis Acids must have lone pair electrons to donate.
*7. (7) Provide a correct systematic (IUPAC) name for the following molecule.

```
4 5 6 7 8 9 10
3
2
1
```
4-ethyl-2-methyl-6-(2-methylpropyl)decane

*8. (4) Convert the following structure into a line (skeletal) structure.

```
\begin{center}
\begin{tikzpicture}
  \node (A) at (0,0) {Br};
  \node (B) at (0,-1) {HO};
  \node (C) at (1,0) {Br};
  \node (D) at (0,-2) {HO};
  \draw (A) -- (B);
  \draw (B) -- (C);
  \draw (C) -- (D);
\end{tikzpicture}
\end{center}
```

*9. (6) For the molecule shown below, state what orbitals are used from both C and N to make the C-N sigma bond of the CN triple bond and from both N and C to make the N-C sigma bond (from N to the methyl).

```
\begin{center}
\begin{tikzpicture}
  \node (A) at (0,0) {sp};
  \node (B) at (1,0) {sp};
  \node (C) at (2,0) {sp\textsuperscript{3}};
  \draw (A) -- (B);
  \draw (B) -- (C);
\end{tikzpicture}
\end{center}
```
The sigma bond in the CN triple bond is made from C\textsubscript{sp} and N\textsubscript{sp} orbitals
The sigma bond in the NC single bond is made from N\textsubscript{sp} and C\textsubscript{sp\textsuperscript{3}} orbitals

*10. (2.5) True or False? The molecule shown below contains no tertiary carbons.

```
(CH\textsubscript{3})\textsubscript{3}CCH(CH\textsubscript{3})\textsubscript{2}
```

*11. (5) Draw both the conjugate acid and conjugate base of CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}OH.

```
\begin{center}
\begin{tikzpicture}
  \node (A) at (0,0) {conjugate acid};
  \node (B) at (0,-1) {conjugate base};
  \node (C) at (0,-2) {O\textsuperscript{+}};
  \node (D) at (0,-3) {H};
  \node (E) at (0,-4) {H};
  \draw (C) -- (D);
  \draw (D) -- (E);
\end{tikzpicture}
\end{center}
```

*12. (4) Which of the following isolated elements has 5 valence electrons?

a) Nitrogen, atomic number 7  
b) Boron, atomic number 5  
c) Fluorine, atomic number 9  
d) Carbon, atomic number 6

*13. (6) Name the molecule shown using systematic naming rules.

```
\begin{center}
\begin{tikzpicture}
  \node (A) at (0,0) {6};
  \node (B) at (1,0) {1};
  \node (C) at (2,0) {2};
  \node (D) at (0,-1) {5};
  \node (E) at (1,-1) {4};
  \node (F) at (2,-1) {3};
  \draw (A) -- (B) -- (C);
  \draw (D) -- (E) -- (F);
\end{tikzpicture}
\end{center}
```
5-ethyl-1,1-dimethyl-2-(2-methylpropyl)cyclohexane
*14. (3) Water has pKₐ = 15.74, and ethyne has pKₐ ~ 25. Will the following reaction take place in the direction written?

\[
\text{H−C≡C−H} + \text{Na}^{+} \cdot \cdot \cdot \text{O−H} \rightarrow \text{H−C≡C}^{\cdot} \cdot \cdot \cdot \text{Na}^{\oplus} + \text{H−O−H} \quad \text{Water}
\]

Ethyne

*15. (4) Which of the compounds below is the strongest base?

\[
\begin{array}{c}
\text{NO} \\
\text{HC} \\
\text{C} \\
\text{H} \\
\end{array}
\]

*16. (4) Which of the following compounds are ionic? (note: more than one positive answer is possible).

a) HCl b) LiF c) IBr d) HH

*17. (3) Which of the following is closest to the C=C=N bond angle in H₂C=C=NH ?

\[
\begin{array}{c}
\text{sp}^3 \\
\text{sp}^2 \\
\text{sp} \\
\end{array}
\]

*18. (7.5) State the hybridization of the atom indicated in each of the following molecules:

\[
\begin{array}{c}
\text{sp}^3 \\
\text{sp}^2 \\
\text{sp} \\
\end{array}
\]

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

a) CH₃NH₃ Stronger base

b) H₄C NH₃ Stronger acid

*20. (7) Using a Newman projection, draw the most stable conformation for 2-methylbutane, viewed along the C2 – C3 bond.

*21. (2.5) Select the answer that tells the character of the bond indicated in the structure.

The O-H bond in CH₃OH (A) nonpolar covalent (B) polar covalent (C) ionic
22. (6) There are three different substances that contain a carbon-carbon double bond and have the formula C₄H₈. Draw two of them.

[diagram of double bonds]

23. (6) Circle the more electronegative element in each of the following molecules.

[diagram of molecules]

24. (3) True or False? For an acid, the general trend is: "the more electronegative the atom, attached to the potentially acidic hydrogen atom, the better the acid".

25. (3) In the molecule below, assign the hybridization of the atom indicated by the arrow.

[diagram of molecule with arrow marked sp]

26. (3) True or False? In the cyclohexane conformer shown, the methyl group is axial.

[diagram of cyclohexane with methyl group marked]

27. (3) Explain briefly but clearly why cyclopropane has bent bonds.

There is a considerable amount of angle strain in cyclopropane because each C is sp³ and should be 109.5°, however, because the molecule has to be flat the angles will be about 60°. This puts angle strain in the molecule, which bends the bonds in plane to try to offset some of the former. There is also torsional strain because of the eclipsed hydrogens but this is not alleviated by the in-plane bend.

28. (6) In what order would the following groups be placed alphabetically when naming an alkane? Use #1 for first in the alphabet, and so on.

tetraethyl ; tert-butyl ; 1,2-dimethylpropyl ; isopentyl

2 1 4 3

29. (3) True or False? The π-bond in a carbon – nitrogen double bond is created by the overlap of p-orbitals.