1. (10.5) State whether each of the following pairs are constitutional isomers, stereoisomers or completely different molecules.

   a) constitutional

   b) different

   c) stereoisomers

2. (8.5) Complete the electron dot structure of caffeine by clearly filling in any non-bonding, valence electrons that are missing from any atom. Also, identify the hybridization of the 3 indicated atoms.

3. (9) State the hybridization of the central carbon atom in each of the following species.

4. (10) Write in any missing charges on any atom in each of the following structures:

5. (3) Which has the stronger conjugate base, methyl amine (pKa = 35) or methanol (pKa = 16)?

6. (5) Explain, briefly but clearly, why BH3 is a strong Lewis Acid. Also, would it be a nucleophile or an electrophile?

   The B in BH3 is neutral but does not have its octet. Accordingly, it can react with a base – sharing 2 electrons from the latter to gain its octet. BH3 is an electrophile.
7. (12) Provide correct systematic (IUPAC) names for each of the following molecules.

a) ![Structure](null)  
3,5-diethyl-2,6-dimethyloctane

b) ![Structure](null)  
2,7,8-trimethyl-6-(1-methylbutyl)decane

8. (7.5) Draw, as line structures, three of the constitutional isomers of formula C₄H₇N. For example:

- ![Structure](null)
- ![Structure](null)
- ![Structure](null)

9. (5) Draw both the conjugate acid and conjugate base of the molecule shown.

- ![Structure](null)  
  conjugate acid

- ![Structure](null)  
  conjugate base

10. (6) Provide a correct, systematic (IUPAC) name for the following molecule.

- ![Structure](null)  
  1,2-diethyl-5-methyl-6-(2-methylpropyl)cyclooctane

11. (4) Write the products of the following acid – base reaction.

\[
\text{CH}_3\text{CH}_2\text{SH} + \text{LiNH}_2 \quad \text{↔} \quad \text{CH}_3\text{CH}_2\text{SLi} + \text{NH}_3
\]
12. (7.5) Which of the following compounds are ionic (at least, in part)? (note: more than one positive answer is possible).

a) LiBF_4  b) HCl  c) CH_3CH_2NHK  d) H_2S  e) CH_3CH_2OH

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

a) CH_4  F\textsuperscript{-}  Stronger base
b) HCl  HBr  Stronger acid

14. (6) Using a Newman projection, draw a staggered conformation for 2-methylbutane, viewed along the C2 – C3 bond.

15. (3) True or False? The C atom in CH_3\textsuperscript{+} is sp_3 hybridized.

16. (6) In each pair, circle the molecule, which would be more stable.

a) BF_3  or  BH_4\textsuperscript{+}  b) NH_2\textsuperscript{-}  or  NH_4\textsuperscript{+}

17. (6) Circle any of the following that are not alkanes?

a) C_8H_{12}  b) C_6H_{14}  c) C_7H_{14}  d) C_6H_6

18. (3) Which of the following isolated elements has seven electrons in its valence shell?

a) Boron, atomic number 5  b) Nitrogen, atomic number 7  c) Oxygen, atomic number 8  d) Fluorine, atomic number 9

19. (4) How many secondary (2°) carbons are in the molecule 2,3,4-trimethylpentane? zero

20. (3) Will the following acid base reaction take place in the direction shown? State yes or no.

CaC_2  +  H\textsuperscript{+}O\textsuperscript{-}H  \rightarrow  H\textsuperscript{+}C\textsuperscript{=}C\textsuperscript{-}H  +  O\textsuperscript{=}=O\textsuperscript{-}H

pK_a \sim 15  \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad pK_a \sim 25
21. (3) **True** or False? The cyclohexane conformation shown is more stable than its “ring flip” conformation.

22. (5) Indicate for each of the following whether they are *cis* or *trans*.

   a) \[
   \begin{array}{c}
   \text{Br} \\
   \text{H} \\
   \text{H} \\
   \text{CH}_3
   \end{array}
   \]
   **trans**

   b) \[
   \begin{array}{c}
   \text{Cl} \\
   \text{H} \\
   \text{CH}_3
   \end{array}
   \]
   **cis**

23. (5) Name the type of reaction (addition, elimination, substitution or rearrangement) involved in each of the following.

   a) \[
   \begin{align*}
   &\text{H} + \text{H}_2 &\rightarrow &\text{H}_3\text{C}_3 \\
   \text{Pd} &\text{addition}
   \end{align*}
   \]

   b) \[
   \begin{align*}
   &\text{H} - \text{C}\equiv\text{C} : \Theta + \text{CH}_3\text{Br} &\rightarrow &\text{H} - \text{C}\equiv\text{C} - \text{CH}_3 + \text{Br} \Theta \\
   \text{substitution}
   \end{align*}
   \]

24. (4) Use arrows to show the reaction between the following nucleophile & electrophile.

   \[
   \begin{array}{c}
   \text{(CH}_3\text{)}_3\text{N} \\
   \text{H}
   \end{array}
   \]

25. (5) Name the orbitals (s,p, sp3 *etc*) from each atom that make up the bonds indicated.

   \[
   \begin{align*}
   &\text{O} &\text{C} &\text{CH} \\
   \sigma\text{-bond} &\rightarrow &\pi\text{-bond}
   \end{align*}
   \]

   \[
   \begin{align*}
   &\text{N} &\text{sp}^3 &\text{C} &\text{sp}^2 \\
   \sigma\text{-bond} &= &\text{Nsp}^3 &- &\text{Csp}^2 \\
   \pi\text{-bond} &= &\text{Cp} &- &\text{Cp}
   \end{align*}
   \]

26. (3) What compound (a-d) is represented by the Newman projection shown?

   a) \[
   \begin{array}{c}
   \text{H} \\
   \text{CH}_3\text{CH}_2\text{CH}_3
   \end{array}
   \]

   b) \[
   \begin{array}{c}
   \text{H} \\
   \text{(CH}_3\text{)}_2\text{CH}\text{CH}_2\text{CH}_3
   \end{array}
   \]

   c) \[
   \begin{array}{c}
   \text{H} \\
   \text{CH}_3\text{CH}(\text{CH}_3)_2
   \end{array}
   \]

   d) \[
   \begin{array}{c}
   \text{H} \\
   \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2
   \end{array}
   \]

   d) \[
   \begin{array}{c}
   \text{H} \\
   \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2
   \end{array}
   \]