Answer all 29 questions (150 pts).

1. (10.5) State whether each of the following pairs are constitutional isomers, stereoisomers or completely different molecules.
   a) ![Structure](image1.png)
   b) ![Structure](image2.png)
   c) ![Structure](image3.png)

2. (6) In each of the following molecules, fill in any non-bonding, valence electrons that are missing from any atom.
   a) ![Structure](image4.png)
   b) ![Structure](image5.png)

3. (6) State the hybridization of the central carbon atom in each of the following species.
   a) ![Structure](image6.png)
   b) ![Structure](image7.png)

4. (8) Write in any missing charges on any atom in each of the following structures:
   a) ![Structure](image8.png)
   b) ![Structure](image9.png)
   c) ![Structure](image10.png)

5. (3) Which has the stronger conjugate base, ammonia (pKa = 35) or methane thiol (pKa = 9)?
   ammonia

6. (3) True or False? Lewis Acids must have protons to donate.
7. (12) Provide correct systematic (IUPAC) names for each of the following molecules.

a) [Diagram of 3,3,5-trimethyloctane]

b) [Diagram of 2,3,6,6-tetramethyl-4-(1-methylpropyl)nonane]

8. (6) Draw, as line structures, three of the 7 constitutional isomers of formula C₄H₁₀O.

For example:

[Diagram of isomers: two alcohols, one ether]

9. (3) True or False? The molecule shown below contains three tertiary carbons.

(CH₃)₂CHCH₂CH(CH₃)CH(CH₃)₂

10. (5) Draw both the conjugate acid and conjugate base of CH₃CH₂NHCH₃.

CH₃CH₂N(CH₃)

11. (4) The compound, BH₃, (Boron, atomic number 5) is a strong Lewis acid. Explain, briefly but clearly.

B has 3 electrons in its valence shell and, accordingly, when it bonds covalently to 3 things it forms a neutral molecule. However, the resultant molecule does not have an octet of electrons on the B and is therefore a strong electron acceptor - Lewis Acid

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

2,4-diethyl-1-methyl-5-(1-methylpropyl)cycloheptane

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

CH₃CH₂OH + NaNH₂ ⇌ CH₃CH₂ONa + NH₃
14. (4) Which of the following compounds are ionic (at least, in part)? (note: more than one positive answer is possible).
   a) NH₃  b) NH₄Cl  c) KBr  d) HF

15. (3) Which of the following is closest to the C=CH-CH bond angle in H₂C=CH-CH=NH?
   a) 180°  b) 120°  c) 109.5°  d) 90°

16. (7.5) State the hybridization of the atom indicated in each of the following molecules:
   a)  
   b)  
   c)  

17. (7) Circle the molecule in each of the following pairs, which best fits the given description.
   a) -CH₃       -OH       Stronger base
   b) H₄N⁺       OH₂        Stronger acid

18. (6) Using a Newman projection, draw a staggered conformation for 2-methylpropane, viewed along the C1 – C2 bond.

19. (6) Circle the more electronegative element in each of the following molecules.
   a) CH₂OCH₂Na  b) FCH₂CH₂CH₂Br  c)  

20. (3) True or False? For a base, the general trend is: "the more electronegative the atom bearing the electrons to be shared, the poorer the base".

21. (4) Which of the following best explains the relative stabilities of the eclipsed and staggered forms of ethane? The ______ form has the most ______ strain.
   a) eclipsed; steric  b) eclipsed; torsional  c) staggered; steric  d) staggered; torsional
22. (4) In what order would the following groups be placed alphabetically when naming an alkane? Use #1 for first in the alphabet, and so on.

isopropyl ; tert-butyl ; 1-methylbutyl ; pentamethyl

2 1 4 3

23. (4) The molecule shown on the left below is much more stable than the molecule shown on the right. Why? Explain briefly but clearly.

Even though both ions have a positive charge, the ion on the left has an octet of electrons on the N atom whereas the N in the molecule on the right does not. An octet makes the species more stable.

24. (6) Write the correct, systematic name for the compound named incorrectly as:

2,2-dimethyl-6-ethylheptane

2,2,6-trimethyloctane

25. (3) What is the general formula for a cycloalkane?

a) C\textsubscript{n}H\textsubscript{n}  b) C\textsubscript{n}H\textsubscript{2n}  c) C\textsubscript{n}H\textsubscript{2n+2}  d) C\textsubscript{n}H\textsubscript{2n-2}

26. (3) Which of the following isolated elements has two unpaired electrons in its valence shell?

a) Carbon, atomic number 6  and / or  c) Oxygen, atomic number 8
b) Nitrogen, atomic number 7  d) Fluorine, atomic number 9

27. (4) How many primary (1\textdegree) carbons are in the molecule 2,3,4-trimethylpentane?

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28. (6) Will the following acid base reactions take place in the direction shown? State yes or no.

\begin{align*}
\text{CH}_3\text{C}^\equiv\text{O}^- & + \text{H}^+\text{O}^- \quad \rightarrow \quad \text{CH}_3\text{C}^\equiv\text{O}^-\text{H}^- & \text{pKa} \sim 15 & \text{NO} \\
\text{CH}_3\text{C}^\equiv\text{O}^- & + \text{H}^+\text{N}^+ \quad \rightarrow \quad \text{CH}_3\text{C}^\equiv\text{O}^-\text{H}^- & \text{pKa} \sim 9 & \text{YES}
\end{align*}

29. (3) In a cyclohexane conformation, the two different positions that a substituent can occupy are called: axial and equatorial