1. Answer the following questions for the molecule below:

![Molecule Image]

a. The number of Sp\(^3\) carbons is: ______4______
b. The number of Sp\(^2\) carbons is: ______4______
c. The number of Sp carbons is: ______2______
d. The number of σ bonds is: _______22____
e. The number of π bonds is: _______4______

2. Draw the following molecules. Show stereochemistry (when necessary).
   a. 3-bromo-2,4-dimethylpentane
      ![Molecule Image]
   b. (Z)-3-methyl-3-hexene
      ![Molecule Image]
   c. 1,4-cyclohexadiene
      ![Molecule Image]
   d. 2-butyne
      ![Molecule Image]
   e. (E)-2,3-dichloro-2-pentene
      ![Molecule Image]
f. Cis-1-chloro-3-methylcyclohexane

3. How many of the methyl groups in the below molecule will occupy an equatorial position in the more stable conformation?

4. Draw a Newman projection of any staggered conformation of 3-bromo-4-methylhexane, viewed down the C³−C⁴ bond.

5. Complete the following Newman projections of the two chair conformations of cis-1,3-dimethylcyclohexane viewed simultaneously down the C³−C⁴ and C₁−C₆ bonds.
6. Draw a wedge-dotted line structure for the molecule below:

![Molecule Structure](image)

7. Indicate the isomeric relationship (constitutional, configurational or conformational) of the following molecules:

a. ![Molecule Structure](image) and ![Molecule Structure](image)

Conformational

b. ![Molecule Structure](image) and ![Molecule Structure](image)

Configurational

c. ![Molecule Structure](image) and ![Molecule Structure](image)

Constitutional

8. Label the acids and bases in the following reaction:

\[
\text{Base} \quad \text{Acid} \quad \text{Conjugate acid} \quad \text{Conjugate Base}
\]

\[
\text{O} + \text{HO-S-OH} \underset{\text{Conjugate acid, Conjugate Base}}{\rightleftharpoons} \text{O} \quad \text{O-S-OH}
\]
9. Label the following configurations as (E) or (Z):

Z    E

10. Draw the major product of the following reactions:

- \( \text{BH}_3 \)
- \( \text{H}_2\text{O}_2, \text{H}_2\text{O} \)
- \( \text{OsO}_4 \)
- \( \text{NaHSO}_3, \text{H}_2\text{O} \)
11. Draw the major product of the following reactions:

\[ \text{H}_2, \text{Lindlar} \quad \rightarrow \quad \text{H}_2/\text{Pt excess} \quad \rightarrow \quad \text{Na, NH}_3 \]

12. Complete the synthesis:

\[ \text{H}_2 \quad \rightarrow \quad \text{NaNH}_2 \quad \rightarrow \quad \text{Br} \quad \rightarrow \quad \text{Na}_2\text{NH}_3 \]

13. Answer the following question for the below compounds:

a) Which one of the above compounds is (2R, 3R)-2,3-dibromobutane?
   A

b) Which two have no plane of symmetry in any conformation?
   A and D
c) Which two are optically active molecules?
   A and D

d) Which two are achiral molecules?
   B and C

e) Which one of the above molecules is identical to:

![Molecule Diagram]

f) Which two will be major product of the following reactions?

![Reaction Diagram]

14. Complete the following reactions and give the MAJOR product.

![Reaction Diagram]
15. When 2,2-dimethyl-4-pentene-1-ol is treated with aqueous Br₂, a cyclic bromo ether is formed rather than the expected bromohydrin. Propose a mechanism, using curved arrows to show electron movement.

16. Draw the two chair conformations of cis-2-bromocyclohexanol. Circle the most stable conformation.

17. Draw an arrow pushing mechanism of the reaction of 1-methylcyclohexene with Br₂. Indicate what the electrophile and what the nucleophile is in each step of the mechanism. Be sure to show stereochemistry of the products.

18. Determine the Elimination products of the following reactions:

\[
\text{E1 product} \quad \text{Sn1 product} \quad \text{E2 product} \quad \text{Sn2 product}
\]
19. How would you synthesize 1-bromohexane from acetylene and any alkyl halide you need?

\[
\begin{align*}
\text{1. NaH} & \quad \text{H}_2, \text{lindlars or} \\
\text{2. } \text{Br} & \quad \text{Na/NaH}_3 \\
\text{1. BH}_3 & \quad \text{1. Br}_3, \text{H}_2\text{O}_2, \text{OH} \\
\text{PBr}_3 & \quad \\
\end{align*}
\]

20. Draw the structure of the S-configuration of 3-methyl-1-pentyn-3-ol.

21. Draw the products of the following reactions.

\[
\begin{align*}
\text{cyclohexane} & \quad \text{HBr(xs)} \quad \text{ether} \\
\text{NBS} & \quad \text{CCl}_4 \\
\text{OH} & \quad \text{SOCl}_2 \\
\end{align*}
\]

22. Rank the following molecules from 1 to 4, with 4 being the least acidic.

\[
\begin{align*}
\begin{array}{cccc}
\text{HCO}_2 & \text{H}_2\text{CO} & \text{HCO}_2 & \text{H}_2\text{O} \\
\text{4} & \text{1} & \text{2} & \text{3}
\end{array}
\end{align*}
\]

23. Identify the following alkenes as E, Z or NA:

\[
\begin{align*}
\text{NA} & \quad \text{Z} & \quad \text{Z} & \quad \text{E}
\end{align*}
\]
24. Draw a reaction energy diagram for a two-step reaction with the first step being rate limiting. The reaction is endergonic. Label the parts of the diagram corresponding with reactants, products, transition state, intermediate and ΔG and ΔG‡. How would the reaction change if the reaction were exergonic?

![Reaction Energy Diagram](image)

dendergonic/endothermic

exergonic/exothermic

25. Complete the following reaction and answer the following questions:

![Reaction](image)

a. Identify the stereochemistry of the starting material as R or S.

b. The above reaction will give two products and in the process will create 2 two new stereocenters. Draw the products and identify the new stereocenters as R or S for each of the two products.

![Products](image)
26. Compound X (C₉H₁₈) reacts with ozone to give two products, A and B. Based on the following IR and ¹H NMR spectral data, deduce the structures of X and A and B.

27. Predict the number of carbon resonance lines (peaks) expected in the ¹³C NMR spectrum of the following molecules:

28. Predict the multiplicity (singlet, doublet, etc) of the ¹H NMR signal for each proton.
29. All of the following compounds have a single $^1$H NMR peak. Approximately where would you expect each compound to appear?

- $\text{O}$
  - $2.0 - 2.5 \text{ ppm}$

- $\text{Cl}$
  - $5.33 \text{ ppm}$

- $\text{H}$
  - $9.0 - 10.1 \text{ ppm}$

- $\text{N}$
  - $2.3 - 3.5 \text{ ppm}$

30. Predict the splitting pattern for each proton in the following compounds.

a. 

b. 

b. 

c. 
31. Draw structures for compounds that meet the following descriptions:
   a. $\text{C}_2\text{H}_6\text{O}$, $^1\text{H}$ NMR: one singlet
      \[\text{O} \\\text{O} \\\text{O}\]
   b. $\text{C}_4\text{H}_8\text{Cl}_2\text{O}$, $^1\text{H}$ NMR: two triplets
      \[\text{Cl} \text{O} \text{O} \text{Cl}\]
   c. $\text{C}_3\text{H}_7\text{Cl}$, $^1\text{H}$ NMR: one doublet and one septet
      \[\text{Cl} \\\text{Cl}\]
   d. $\text{C}_4\text{H}_8\text{O}$, $^1\text{H}$ NMR: one singlet, one triplet and one quartet
      \[\text{O} \\\text{O} \\\text{O}\]
32. Deduce the structure of the following unknown structure with the formula C_{11}H_{14}O:
   IR: 1720 cm\(^{-1}\) (strong); 1550 cm\(^{-1}\)
   \(^1\)H NMR: \(\delta\) 7.2, singlet (5H)
   \(\delta\) 2.4, triplet (2H)
   \(\delta\) 2.3, quartet (2H)
   \(\delta\) 2.2, triplet (2H)
   \(\delta\) 1.0, triplet (3H)

33. Deduce the structure of the following unknown structure with the formula C_{4}H_{8}O_{2}:
   IR: 1715 cm\(^{-1}\) (strong);
   \(^1\)H NMR: \(\delta\) 4.1, quartet (2H)
   \(\delta\) 2.1, singlet (3H)
   \(\delta\) 1.3, triplet (3H)

34. Deduce the structure of the following unknown structure with the formula C_{4}H_{10}O:
   IR: 3300 cm\(^{-1}\) (strong);
   \(^1\)H NMR: \(\delta\) 3.7, singlet (1H)
   \(\delta\) 3.5, doublet (2H)
   \(\delta\) 1.5, septet (1H) \textit{should have been a multiplet.}
   \(\delta\) 0.9, doublet (6H)

35. Determine the other product formed from this reaction.
36. Complete the following syntheses.