Answer all questions (150 pts).

1. (10) Name the following molecules using IUPAC rules. Where appropriate, assign E or Z designations.
   a) 
   b) 

2. (3) What is the IUPAC name of the compound shown below?
   a) Nonane
   b) 2,3,5-trimethylhexane
   c) 2,6-dimethylheptane
   d) 1,1,2,4,4-pentamethylbutane

3. (3) How many secondary carbon atoms are present in the molecule shown?
   a) zero
   b) one
   c) two
   d) five

4. (3) How many different monochloro derivatives are possible for the molecule shown?
   a) three
   b) four
   c) five
   d) six

5. (3) What compound (a-d) is represented by the Newman projection shown?
6. (3) Which of the following describes the most stable conformer of cis-1-tert-butyl-2-methylcyclohexane?
   a) The tert-butyl group is equatorial and the methyl group is axial
   b) The tert-butyl group is axial and the methyl group is equatorial
   c) Both groups are equatorial
   d) Both groups are axial

7. (3) The degree of unsaturation (rings and/or multiple bonds) for the formula C₇H₄Cl₂N₂O₄ is:
   a) 4   b) 5   c) 6   d) 7

8. (3) What is the relationship between these structures?
   a) constitutional isomers
   b) same compound
   c) enantiomers
   d) diastereomers

9. (6) Circle any of the following which are chiral.
   a)
   b)
   c)
   d)

10. (9) Show an arrow (or arrows) indicating the movement of electrons (sharing) between each of
    the reaction pairs shown. You need not show the consequence of your arrows.
11. (3) If a molecule has 7 stereogenic centers and 2 of the possible stereoisomers are meso, there will be how many stereoisomers in total?

a) $2^7$  

b) $7^2 - 2$  

c) $2^7 - 2$  

d) $2^2 - 7$  

e) $2^7 - 2$

12. (3) Which of the following is the major organic product of the reaction shown?

![Reaction diagram]

a) 

b) 

c) 

d) 

13. (2.5) True or False? The pKa of a proton attached to the C of a terminal alkyne is more acidic than that in NH$_3$.

14. (2.5) True or False? An achiral molecule must have a superimposable mirror image.

15. (4.5) For the following, circle all of the statements to the right which are correct.
16. (8) By assigning priorities to the groups attached, designate either E or Z or R or S (as appropriate) to each of the following molecules. You must show all the priorities (#1 = highest) to receive full credit.

![Molecule diagram](image)

17. (3) Which carbocation would you predict to be the least stable?

<table>
<thead>
<tr>
<th>CH₃CH=CHCH₂</th>
<th>CH₃</th>
<th>CH₃CHCHCH₃</th>
<th>CH₃CH₂CH₂</th>
<th>CH₃CH₂CCH₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>

18. (9) The Molecule (A), shown below, reacted with NaCN in acetone as solvent to yield a single product (B) {optical rotation +20°}. However, treatment of (A) with CH₃OH gave 2 products, (C) and (D) {optical rotations +37° and -37°, respectively}. Draw products (B), (C) and (D) and explain briefly, but clearly, what type of reaction is taking place in each case and why this would lead to the outcome described.
19. (3) Which Fischer projection is the same as the molecule in the box?

(A) (B) (C)

20 (3) The molecule in the box has what configuration? (A) R (B) S

21. (40) In each of the following reactions reactants or products are missing. Fill in the blanks with the appropriate molecules. If more than one step is involved, indicate this by using 1)......; 2)....... If more than one product could be formed, show only the major product(s). Where appropriate, draw the stereochemistry of the product(s).

a)

b)
22. (7.5) For each of the following pairs, circle all of the statements to their right which are correct.

a) \[
\begin{align*}
\text{H}_2\text{N} & \text{Cl} \\
\text{CH}_3 \\
\text{H}_3\text{C} & \text{NH}_2
\end{align*}
\]
and
\[
\begin{align*}
\text{HO} & \text{Cl} \\
\text{H}_2\text{O} \\
\text{HO} & \text{CHO}
\end{align*}
\]

- mirror images
- diastereomers
- identical
- constitutional isomers
- enantiomers

b) \[
\begin{align*}
\text{CHO} & \text{HO} \\
\text{HO} & \text{CHO}
\end{align*}
\]

- mirror images
- diastereomers
- identical
- constitutional isomers
- enantiomers

23. (8) Show the steps / reactants involved in the synthesis of the product shown from the given starting material.
24. (5) From the molecule shown, draw a Newmann projection by viewing the molecule along the central C-C bond as designated below.

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