1. (10%) Draw structures of the following showing stereochemistry if appropriate:
   a. s-butyl alcohol
   b. isobutyl isopropyl ether
   c. p-nitrophenoxide ion
   d. (S)-3-hexanol
   e. meso-2,3-dihydroxybutane

2. (3%) Determine if the following compound is (R) or (S).

3. (8%) Mark each stereocenter (chiral carbon) in the compounds below with an asterisk * AND give the maximum number of possible stereoisomers for each compound.

\[
\text{CH}_2=\text{CHCHICH(CH}_3\text{)CHFCH}_2\text{CH}_2\text{OH}
\]

Pregnenolone
4. (14%) Encircle the correct answer:

a. More soluble in water: \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) or \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \)

b. Higher boiling point: \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) or \( \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 \)

c. More soluble in water: \( \text{CH}_3\text{CH}_2\text{CH(OH)}\text{CH}_2\text{CH}_3 \) or \( \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \)

d. Optically active: 50/50 mixture of two diastereomers or 50/50 mixture of two enantiomers

e. Enantiomer of

f. Optically active diastereomer:

g. 1,2-Epoxycyclohexane (cyclohexene oxide) plus aqueous acid yields:

h. Stronger acid: \( \text{CH}_3\text{CH}_2\text{OH} \) or \( \text{CF}_3\text{CH}_2\text{OH} \)

i. Better leaving group: \(-\text{SCH}_3\) or \(-\text{S(CH}_3)_2\)\(^{+1}\)

j. Better nucleophile: \(-\text{Br}^{-}\) or \(-\text{I}^{-}\)

k. Reacts faster in S\(_\text{N}\)\(_\text{2}\) reaction: \( \text{(CH}_3\)\(_3\)\text{CBr} \) or \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} \)

l. Reacts faster in S\(_\text{N}\)\(_\text{1}\) reaction: \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) or \( \text{(CH}_3\)\(_3\)\text{COH} \)

m. Reacts faster in S\(_\text{N}\)\(_\text{1}\) reaction:

n. Diastereomer of
5. (6%) For each of the following, state if the operating mechanism is S_N1, S_N2, E1, or E2, or if the mechanism can’t be determined from the given data.

Reaction is: R-X + Y^- --> ? (There are no other functional groups in R.).

a. ________ Rate = k [R-X] and the product is an alkene.

b. ________ Optically active R-X gives optically active R-Y.

c. ________ CH_3CH_2CH_2CH_2-X gives predominantly CH_3CH=CHCH_3.

d. ________ (CH_3)_3CCHXCH_3 --> (CH_3)_2C=C(CH_3)_2.

e. ________ t-Amyl iodide and the bromide ion gives t-amyl bromide at the same rate as t-amyl iodide and the chloride ion gives t-amyl chloride.

f. ________ (CH_3)_3CCHXCH_3 ---> (CH_3)_2CHCY(CH_3)_2

6. (6%) Dehydrohalogenation of the following bromide using alcoholic KOH goes under E2 conditions.

a. Give the structure of the product being careful to show stereochemistry.

b. Give the mechanism of the reaction using the curved arrow notation.
7.  (6%) Give simple chemical tests which will differentiate between the members of the following pairs. Give the formulas of the compounds you would ADD and tell what you would SEE.

    a. 
    b. 

8.  (7%) Give the mechanism of the following transformation (curved arrow notation, of course):

\[ \text{Cl} \quad \text{Br}^{-1} \quad \Delta \quad \text{Br} \]

9.  (7%) Encircle the deactivating groups and underline the ortho,para-directors for electrophilic aromatic substitution reactions.

\[ -\text{N}^+\text{C}^+\text{CH}_3 \quad -\text{O}^+\text{N}^+\text{CH}_3 \quad -\text{C}_2\text{H}_5 \quad -\text{Br} \quad -\text{CF}_3 \quad -\text{NH}_2 \quad -\text{NH}_3^{+1} \]
10. (12%) Outline syntheses of the following compounds starting from acetylene, benzene, ethanol, and methanol and as your only source of carbon atoms.

a. \(\text{O} \quad \text{O} \)

b. \(\text{OH} \quad \text{OH} \)

c. \(\text{CO}_2\text{H} \quad \text{NO}_2 \)
11. (4%) The -OH group is an ortho,para- director in electrophilic aromatic substitution. At first glance this seems to be inconsistent with the inductive effect of the electronegative oxygen. However, the reality of the directive effect of -OH can be easily explained by considering resonance effects. Draw the key resonance contributor that explains the directive behavior of the -OH group and note what is so special about this contributor (as compared to the other contributors).

12. (7%) Optically active A, C₆H₁₁Br, was treated with a solution of KMnO₄ and no precipitate formed. A was treated with alcoholic potassium hydroxide and gave two optically inactive isomers, B and C, C₆H₁₀. Treatment of B with hot, acidic potassium permanganate gave D, C₃H₄O, and E, C₃H₆O₂. Treatment of C with hot, acidic potassium permanganate gave F, C₄H₆O₂, and G, C₂H₄O₂. F had only three peaks in the C-13 nmr spectrum. Give logical structures of A, B, C, D, E, F, and G.

13. (10%) Compare and contrast the S_N1 and S_N2 mechanisms for the hypothetical reaction:

\[ R-X + Nu^- \rightarrow R-Nu + X^- \]

by giving the following factors for each mechanism (short but complete answers are satisfactory):

\[ \begin{array}{cc}
S_N1 & S_N2 \\
\end{array} \]

a. Rate Equation

b. Stereochemical Outcome

c. Relative rates of 1° vs. 3° substrate

d. Possibility of Rearrangements

e. Give mechanisms for each using the curved arrow notation