1. [21 pts] Draw the major product formed or provide the reagent necessary to do the desired transformations in each of the following reactions. You may assume standard conditions to achieve a neutral stable product.

a. \[
\begin{align*}
\text{OH} & \\
\text{CH}_3\text{SO}_2\text{Cl}, \text{pyridine} & \\
\text{OH}
\end{align*}
\]

b. \[
\begin{align*}
\text{O} & \\
\text{OH} & \\
\text{HO}
\end{align*}
\]

c. \[
\begin{align*}
\text{OH} & \\
\text{OH} & \\
\text{KMnO}_4, \text{H}_3\text{O}^+ & \\
\text{OH}
\end{align*}
\]

d. \[
\begin{align*}
\text{OH} & \\
\text{OCH}_3 & \\
\text{Cl} & \\
\text{OCH}_3
\end{align*}
\]

e. \[
\begin{align*}
\text{O} & \\
\text{CH}_3\text{MgBr} & \\
\text{H}
\end{align*}
\]

f. \[
\begin{align*}
\text{OH} & \\
\text{OH}
\end{align*}
\]

g. \[
\begin{align*}
\text{H}_3\text{CO} & \\
\text{NaBH}_4 & \\
\text{H}_2\text{CO}_2\text{H}
\end{align*}
\]
2. [10 pts] Name the following compounds according to IUPAC nomenclature:
   a. 
   ![Chemical Structure]
   b. 
   ![Chemical Structure]

3. [6 pts] In each of the molecules shown below, circle the two different functional groups and identify what type each is (i.e. halide, alcohol, ketone, etc).
   ![Chemical Structures]

4. [6 pts] For each transformation shown, label as an oxidation, a reduction or neither:
   a. 
   ![Chemical Transformation]
   b. 
   ![Chemical Transformation]
   c. 
   ![Chemical Transformation]
5. [28 pts] Synthesis: For the first three synthesis problems, fill in the missing reagents or intermediate structures for each of the following sequences:

a. 

\[ \text{I} \xrightarrow{} \text{OH} \xrightarrow{} \text{H} \]

b. 

\[ \text{OH} \xrightarrow{\text{PBr}_3} \xrightarrow{\text{Mg}} \]

c. 

\[ \text{OH} \xrightarrow{} \text{H} \xrightarrow{} \text{Br} \]
Synthesis (continued): For the final synthesis question, you need to provide the correct reagents, in the correct order, to complete the desired transformation. No intermediates need to be shown. Count your carbons carefully...

d.

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO} & \xrightarrow{\text{H}_2\text{O}} \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \\
\end{align*}
\]


\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH} & \xrightarrow{\text{H}_2\text{O}, \text{H}^+} \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \\
\end{align*}
\]
7. [12 pts] Sequence Question: Identify the structures of the Compounds A, B, C and D formed in the following sequence of reactions.

a. 1,4-Pentanediol is reacted with one equivalent of trimethylsilyl chloride and triethylamine to form Compound A.

b. Compound A is oxidized using PCC and then reacted with methyl magnesium bromide, CH₃MgBr, to form Compound B.

c. The addition of fluoride anion to Compound B results in the formation of Compound C, which then can easily react with thionyl chloride and pyridine to form Compound D, C₆H₁₃OCl.

d. Compound D will react with NaH or KH to form the following cyclic ether in a Williamson ether synthesis reaction:

$$\text{Compound D} \xrightarrow{\text{NaH}} \text{O}$$

8. [8 pts] Thought Provoking Questions (a.k.a. Short Answers): Choose 2 of the 3 following questions. If you answer more than two, indicate which two you wish to be graded otherwise the first two will be chosen for you.

a. Explain why a primary alcohol, like 1-pentanol shown below, cannot be converted into a primary chloride, using the reagent HCl.

$$\text{CH₂CH₂CH₂CH₂CH₂OH} \xrightarrow{\text{HCl}} \text{CH₂CH₂CH₂CH₂CH₂Cl}$$
b. In the following transformation, should the alcohol be converted into a halide or a tosylate to achieve the desired product? Explain your answer.

\[
\begin{align*}
\text{OH} & \xrightarrow{1. \ ?} \xrightarrow{2. \ \text{NaOCH}_3} \text{OCH}_3 \\
\text{alkyl groups} & \text{alkyl groups}
\end{align*}
\]

c. Explain why increasing the number of alkyl groups surrounding an alcohol decreases the acidity of the alcohol proton.