What are the products of the following reactions? Indicate stereochemistry as appropriate. (4 pts each)

1. propyne $\xrightarrow{\text{aq. } H_2SO_4} \xrightarrow{\text{NaOI}} HgSO_4$ (I$_2$ / base)

2. 

3. $\xrightarrow{\text{CH}_2N_2}$

4. $\xrightarrow{\text{H}^+ \text{ Br}^-}$

5. $\xrightarrow{\text{Li}} \xrightarrow{\text{CuX}} \xrightarrow{\text{PhCOCl}}$

20 pts
6. \[ \begin{align*}
&\text{CH}_3 \quad \text{B}_2\text{H}_6 \quad \text{H}_2\text{O}_2 \\
&\text{base}
\end{align*} \]

(4 pts)

7. (8 pts) Consider the free radical chlorination of methane to yield chloromethane and hydrogen chloride.

\[ \text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl} \]

The energy of activation for the rate-determining step is known to be about 4 kcal/mol. Presented below are two alternative chain mechanisms for the process. Making use of the bond dissociation energies tell why mechanism 1 is more likely than mechanism 2.

<table>
<thead>
<tr>
<th>Chain Step A</th>
<th>Mechanism 1</th>
<th>Mechanism 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH(_4) + Cl \rightarrow CH(_3) + HCl</td>
<td>CH(_4) + Cl \rightarrow CH(_3)Cl + H</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chain Step B</th>
<th>Mechanism 1</th>
<th>Mechanism 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH(_3) + Cl(_2) \rightarrow CH(<em>3)Cl + Cl(</em>-)</td>
<td>H(_+) + Cl(<em>2) \rightarrow HCl + Cl(</em>-)</td>
<td></td>
</tr>
</tbody>
</table>

Some Bond Dissociation Energies

<table>
<thead>
<tr>
<th>Bond</th>
<th>BDE (kcal/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH(_3)-H</td>
<td>104</td>
</tr>
<tr>
<td>H-Cl</td>
<td>103</td>
</tr>
<tr>
<td>Cl-Cl</td>
<td>58</td>
</tr>
<tr>
<td>CH(_3)-Cl</td>
<td>84</td>
</tr>
</tbody>
</table>
Provide a synthesis of the following compounds starting with alcohols having four or fewer carbons, benzaldehyde, (PhCHO), solvents, TsCl or any inorganic. You may also use a compound from an earlier problem even if you were not able to give a synthesis for the earlier compound. (8 pts each)

8. The ketal shown below

\[
\begin{array}{c}
\text{O} \\
\text{O} \\
\text{O}
\end{array}
\]

9. diphenylethyne

\[
\begin{array}{c}
\text{Ph} \\
\text{Ph}
\end{array}
\begin{array}{c}
\text{C} \\
\text{C}
\end{array}
\begin{array}{c}
\text{Ph} \\
\text{Ph}
\end{array}
\]

10. meso 1,2-diphenyl-1,2-ethanediol

\[
\begin{array}{c}
\text{Ph} \\
\text{H} \\
\text{H} \\
\text{Ph}
\end{array}
\begin{array}{c}
\text{OH} \\
\text{OH}
\end{array}
\]

24 pts
11. Identify the following compound \((C_8H_9Br)\) from the following nmr spectrum. (10 pts)

12. a) During the preparation of triphenylmethanol a number of low volatility (high boiling point) impurities are produced. They were removed by boiling the reaction mixture with water. How does this remove the impurities? (4 pts)

b) During the oxidation of a secondary alcohol with dichromate the temperature of the reaction mixture was kept between 25 and 40 degrees. Explain why this was needed. (4 pts)

14 pts
13. Identify the following compound \((C_{10}H_{12}O)\) from the nmr spectrum given below. (10 pts)

answer:

10 pts
14. What physical process is involved in.
   a) nmr spectroscopy
   b) ir spectroscopy
   c) uv spectroscopy
   d) mass spectroscopy

15. Which of the following compounds will have the highest heat of hydrogenation (most exothermic) for one mole of the compound? Which will have the lowest (least exothermic)? Answer by letter. (3 pts each)

16. Which of the following isomers of dimethylocyclohexane is the most stable? Which is least stable? Answer by letter. (3 pts each)