1. Predict the:
   - $^1$H NMR spectrum [include approximate chemical shifts (1’s, 2’s, 3’s, 4’s, 5’s, etc.), integration, and splitting]
   - $^{13}$C NMR spectrum [include approximate chemical shifts (0-50, 50-100, 100-150, or 150-220) and splitting]
   - identify any distinctive signals in the IR spectrum

Example:

CH$_3$CH$_2$OCH$_3$

\[
\begin{array}{ccc}
\text{H NMR} & \text{C NMR} & \text{IR} \\
1’s & 3H & t & 0-50, q & \text{none} \\
3’s & 2H & q & 50-100, t \\
3’s & 3H & s & 50-100, q \\
\end{array}
\]

2. For the following molecule,
   - Write how many “types” of H’s there would be in the $^1$H NMR spectrum (these are H’s which might coincidentally overlap, but can’t be assumed to be chemical shift equivalent)
   - Write how many different $^{13}$C NMR absorptions you would expect, and
   - Write what the $^{13}$C NMR splitting would be, i.e. singlet, doublet, triplet, or quartet for the $^{13}$C NMR absorptions.

Example:

\[
\begin{array}{ccc}
\text{Number of Nonequivalent } & \text{Number of }^{13}\text{C Absorptions} & \text{Expected Splitsings} \\
\text{H’s in H-NMR} & \text{in }^{13}\text{C NMR} & \text{in }^{13}\text{C NMR} \\
3 & 4 & \text{q, t, s, q} \\
\end{array}
\]

\[
\begin{array}{ccc}
\text{Number of Nonequivalent } & \text{Number of }^{13}\text{C Absorptions} & \text{Expected Splitsings} \\
\text{H’s in H-NMR} & \text{in }^{13}\text{C NMR} & \text{in }^{13}\text{C NMR} \\
\text{H}_3\text{C-O} & \text{in }^{13}\text{C NMR} & \text{in }^{13}\text{C NMR} \\
\end{array}
\]
Provide Structures Based on the Following Spectroscopic Data  (8 points each)

4. C₅H₁₀O₂
5. $\text{C}_{10}\text{H}_{14}\text{O}$

$^{13}\text{C NMR:}$

<table>
<thead>
<tr>
<th>148 s</th>
<th>135 d</th>
<th>75 q</th>
<th>50 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>122 s</td>
<td>128 d</td>
<td>22 q</td>
<td></td>
</tr>
</tbody>
</table>
6. C₅H₁₀O₂
IR: 1710 (strong), 3300-3500 (broad, strong)
7. C₅H₁₁Cl

\(^{13}\text{C NMR}: \ 60 \ (\text{d}), \ 40 \ (\text{t}), \ 37 \ (\text{t}), \ 33 \ (\text{q}), \ 20 \ (\text{q})\)
8. C₃H₁₂O
9. \( \text{C}_4\text{H}_8\text{O}_2 \)

- triplet, 1.02, 3H
- sextet, 1.43, 2H
- triplet, 2.35, 2H
- singlet, 10.95, 1H

IR 1715 cm\(^{-1}\) and broad 2500-3000