Please use other paper and answer the following three questions.

1. A compound has either structure I or structure II, as shown below. Data from the 300 MHz proton spectrum is given in the table. Which of these two isomers is consistent with the data? Explain your answer and assign the spectrum.

![Structures I and II](image)

<table>
<thead>
<tr>
<th>Peak</th>
<th>Chemical Shift</th>
<th>Integration</th>
<th>Multiplicity</th>
<th>Coupling Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.88 ppm</td>
<td>1 H</td>
<td>t</td>
<td>2.8 Hz</td>
</tr>
<tr>
<td>B</td>
<td>3.46</td>
<td>2 H</td>
<td>t</td>
<td>9.6</td>
</tr>
<tr>
<td>C</td>
<td>3.36</td>
<td>2 H</td>
<td>dd</td>
<td>2.8, 9.6</td>
</tr>
<tr>
<td>D</td>
<td>3.10</td>
<td>1 H</td>
<td>t</td>
<td>9.6</td>
</tr>
</tbody>
</table>

2. Answer the following questions:

a. Draw the proton-decoupled $^{13}$C NMR spectrum you would expect for a $^{13}$C nucleus coupled to one $^2$H nucleus.

b. Draw the proton-decoupled $^{13}$C NMR spectrum you would expect for a $^{13}$C nucleus coupled to two equivalent $^2$H nuclei.

For the remaining questions in this problem, consider the 90-τ-180 pulse sequence.

c. Describe how the vectors change in the rotating frame of reference for a $^{13}$C nucleus coupled to one $^2$H nucleus. (Assume the multiplet is on resonance.)

d. Describe how the vectors change in the rotating frame of reference for a $^{13}$C nucleus coupled to two equivalent $^2$H nuclei. (Assume the multiplet is on resonance.)

e. For each case above, show how the vectors will be aligned for $\tau = 1/(4J)$ sec and for $\tau = 1/(2J)$ sec.

f. Assuming these are aliphatic groups, what would be the approximate delay times in part e in milliseconds?
3. Shown below is the 22.5 MHz $^{13}$C NMR spectrum of Cl$_2$CHSi(CH$_3$)$_3$ as follows:

(a) fully proton-coupled; (b) expansion of upfield multiplet; (c) expansion of the second member of the quartet in (b); (d) expansion of the downfield multiplet; (e) expansion of the halves of the “doublet” shown in d.

1. What is the approximate resonance frequency of protons on this spectrometer?
2. Assign the $^{13}$C NMR spectrum. Explain your answer.
3. Explain the various multiplicities of the peaks.