Both of the isomers have a plane of symmetry, resulting in equivalences for a number of the protons that are consistent with the number of peaks (4) and the relative integrations (1:2:2:1).

The expected coupling patterns for each isomer are shown below. These are based on a large (9.6 Hz) coupling for axial-axial 3-bond couplings, but smaller (2.8 Hz) coupling for axial-equatorial.

**Isomer II** is consistent with the data. **Isomer I** is not.
(35) \[ \begin{array}{cc}
\text{a) } & C^{-2}H \quad \text{b) } C^{-2}H_2 \\
\end{array} \]

\[ \begin{array}{c}
\text{c) } \quad \text{During } \gamma: \quad \text{center peak remains on } y' \quad \omega = 2\pi (\gamma_a - \gamma_b) = \frac{2\pi J \text{ rad}}{\text{sec}} \\
\text{one peak rotates at } \frac{2\pi J \text{ rad}}{\text{sec}} \quad \text{other peak rotates at } -\frac{2\pi J \text{ rad}}{\text{sec}} \\
\end{array} \]

\[ \begin{array}{c}
\text{e) } \quad \text{Fm } C^{-2}H \text{ triplet:} \\
\gamma = \frac{1}{45} \sec: \quad \left( \frac{2\pi J \text{ rad}}{\text{sec}} \right) \left( \frac{1}{45} \sec \right) = \frac{\pi}{9} \text{ rad at } 90^\circ \\
\end{array} \]

\[ \gamma = \frac{1}{25} \sec: \quad \left( \frac{2\pi J \text{ rad}}{\text{sec}} \right) \left( \frac{1}{25} \sec \right) = \pi \text{ rad at } 180^\circ \\
\]
d) $C^{2}H_{2}$ pentuplet:

During $\theta$: Center peak remains on $y'$

\[ \omega = 2\pi \left( v_{a} - v_{b} \right) = 2\pi \frac{v_{a}}{\text{sec}} \]

Next 2 peaks rotate @ $\pm \frac{2\pi}{v_{a}} \frac{\text{rad}}{\text{sec}}$

\[ \omega = 2\pi \left( v_{a} - v_{b} \right) = 2\pi \frac{25}{\text{sec}} = 4\pi \frac{\text{rad}}{\text{sec}} \]

0 when 2 peaks rotate @ $\pm \frac{4\pi}{v_{a}} \text{rad/ sec}$

It allowed to process for another period $\theta$, the peaks would come together on the $-y'$ axis.

e) For $C^{2}H_{2}$ pentuplet:

\[ \theta = \frac{1}{45} \text{sec} \]

Center peak on $y'$

Next 2 peaks:

\[ \left( \frac{2\pi}{\text{rad}} \right) \left( \frac{1}{45} \text{sec} \right) = \frac{\pi}{2} \text{ rad in 90°} \]

Outer 2 peaks:

\[ \left( \frac{4\pi}{\text{rad}} \right) \left( \frac{1}{45} \text{sec} \right) = \pi \text{ rad in 180°} \]

\[ \theta = \frac{1}{25} \text{sec} \]

Center peak on $y'$

Next 2 peaks:

\[ \left( \frac{2\pi}{\text{rad}} \right) \left( \frac{1}{25} \text{sec} \right) = \pi \text{ rad in 180°} \]

Outer 2 peaks:

\[ \left( \frac{4\pi}{\text{rad}} \right) \left( \frac{1}{25} \text{sec} \right) = \frac{2\pi}{5} \text{ rad in 360°} \]

f) $J_{12}^{2} - J_{12}^{4} = \frac{v_{a}}{8.4} \text{ Hz} = 125 \text{Hz} = 19.2 \text{ Hz}$

\[ J = \frac{2}{45} \left( 95.24 \text{ m/sec} \right) = 13 \text{ m/sec} \]

\[ \frac{1}{J} = \frac{2}{45} (19.2 \text{ Hz}) = 26 \text{ m/sec} \]
1. Approx. resonance freq. of protons = \( (22.5 \text{ MHz}) \frac{\gamma_H}{\gamma_{1H}} = (22.5 \text{ MHz}) \left( \frac{26.770}{6.723} \right) \)

\[ = (22.5 \text{ MHz})(3.98) \]

\[ = 89.5 \text{ MHz} \]

2. \( \text{Cl}_2\text{H}_3 \text{Si} \left( \text{CH}_3 \right)_3 \)
   - Doublet @ 64 ppm (large, on-bond coupling, consistent with relative size and chemical shift)
   - Quartet @ -4 ppm (large, on-bond coupling to 3 H's would result in quartet, also consistent with upfield shift for carbon bonded to silicon and relative shift)

3. Only coupling will be to H's; Cl relaxes too rapidly to observe coupling, Si may produce very small satellite that does not contribute significantly to the major observed coupling due to low abundance

\[ \text{Peak @ 64 ppm} \]

\[ \text{J_{3J}C-H} \]

\[ \text{Each split into a 10-line multiplet by 9 H's, other bonds away} \]

\[ \Theta(g) + 1 = 9 \]

\[ \Theta(5g) + 1 = 10 \]

- You can only see 8 of the 10 lines to some extent, but it is clear that there are 10 spins

\[ \text{Peak @ -4 ppm} \]

\[ \text{Split into seven lines by six protons} \]

\[ \text{Each split into a doublet by a single H on chlorinated carbon} \]

\[ \text{J_{3J}C-H} \]