Problem R-310 (C<sub>11</sub>H<sub>19</sub>Cl<sub>2</sub>F<sub>2</sub>). Interpret the 56.4 MHz <sup>19</sup>F NMR spectrum below (CCl<sub>4</sub> solvent). Determine the chemical shifts of the fluorines, and estimate the various coupling constants. Consider conformations of the cyclobutane ring (Source: *J. Am. Chem. Soc.* 1962, 84, 2935; digitized hard copy).

(a) 56.4 MHz <sup>19</sup>F NMR spectrum

(b) Interpret the 60 MHz <sup>1</sup>H NMR spectrum
Problem R-310 (C₁₁H₁₀Cl₂F₂). Interpret the 56.4 MHz ¹⁹F NMR spectrum below (CCl₄ solvent). Determine the chemical shifts of the fluorines, and estimate the various coupling constants. Consider conformations of the cyclobutane ring (Source: *J. Am. Chem. Soc.* 1962, 84, 2935; digitized hard copy).

(a) 56.4 MHz ¹⁹F NMR spectrum

\[
\text{ddd, } J = 187, 9.5, 1.9 \text{ Hz}
\]

\[
\nu_{F-F} = 435 \text{ Hz}
\]

\[
\delta_{F-F} = 7.71 \text{ ppm}
\]

\[
J_{F-F} = 187 \text{ Hz}
\]

an ABXYZ₃ system

\[
J_{F-H} = 2 \text{ Hz}
\]

\[
J_{F-H} = 187 \text{ Hz}
\]

\[
J_{F-H} = 9.4
\]

\[
J_{F-H} = 1.8
\]

\[
J_{F-H} = 13.7 \text{ Hz}
\]

H-F couplings also follow a Karplus-like relationship, with large coupling when θ is 0 or 180°

(b) 60 MHz ¹H NMR spectrum

\[
\text{AB of ABXY, } J_{AB} = 13.5 \text{ Hz (AB = H; XY = F)}
\]

\[
J_{HF} = 20, 10 \text{ Hz}
\]

\[
J_{HF} = 14, 2 \text{ Hz}
\]

\[
J_{AB} = 5.00
\]

\[
J_{AB} = 2.19
\]

\[
J_{AB} = 2.94
\]