Problem of the Month:
December 2019

\(^1\text{H}\{^{19}\text{F}\} \text{ HOESY NMR}
(600 MHz, 700 ms)

\(^1\text{H}\) chemical shifts: 6.76 (dd), 6.53 (dd), 4.77 (s), 4.53 (q)

\(^{19}\text{F}\) chemical shift: -72.7
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Strategy

(1) HOESY (Heteronuclear Overhauser Effect Spectroscopy) experiments allow detection of spatial proximity between NMR-active nuclei of different isotopes. The title spectrum shows interactions between $^{1}$H and $^{19}$F atoms that are no further apart than ca. 5 Å.

(2) On the next page, an ‘edited‘ HSQC is given. I.e. CH and CH$_{3}$ groups show positive cross peaks, CH$_{2}$ groups produce negative cross peaks. Quaternary carbons, as well as exchangeable protons, generate no cross peaks. $^{1}$H integrals are indicated by blue numbers underneath the projection.

(3) Also, you might calculate the degree of unsaturation (DBE) from the molecular formula: C$_{8}$H$_{8}$F$_{3}$NO.
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H,C HSQC @ 600/150 MHz
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H,C HMBC @ 600/150 MHz
Hints

(1) Connectivity between fragments is derived from the H,C HMBC experiment (rule of thumb: for sp² carbons, $^{3}J_{CH}$ cross peaks are more intense than $^{2}J_{CH}$ cross peaks).

(2) There are two types of spin systems in this molecule, each coupling over three bonds - they can be identified from carefully analysing the 1D $^{1}$H spectrum on depicted on top of the HSQC experiment, and from H,H COSY and H,F COSY spectra (see next page).
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H,H COSY

H,F COSY
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Solution

(1) The molecule of December contains a homonuclear, aromatic AA′XX′ spin system and a heteronuclear, aliphatic A₂X₃. The exchangeable amine proton has a long range coupling on the corresponding, quaternary carbon. Assignment of the aromatic part is possible through HMBC correlations, note the F,C splitting of the CF₃ group.

(2) On nmr.cheminfo.org, there is a tool to simulate ¹H NMR spin systems: In the forth row, compare with simulate spin system’an AB (A₂X₂ case) vs. an ABCD system (AA′XX′ case) for the aromatic part [so far, heteronuclei and exchangeable hydrogens cannot be considered].

(3) If you are still in doubt - the correct structure will be uploaded in nmrshiftdb as a new entry in January 2020.