Problem NMR12.

For each of the following structures, indicate how many peaks would be found in the $^{13}$C spectrum.

![Chemical structures](image)

Problem NMR13.

Sketch the expected $^{13}$C spectrum for each of the structures in the previous question.

Problem NMR14.

Suggest possible assignments for peaks found at the following positions in the $^{13}$C NMR spectrum.

a) 63 ppm  b) 114 ppm  c) 205 ppm  d) 35 ppm  e) 165 ppm  f) 175 ppm

Problem NMR15.

Suggest the approximate chemical shift for the circled carbons in the following partial structures.
Problem NMR16.

Explain why, in the following cases, chemical shift is slightly different from the normal range described.

a) chlorofom (CHCl₃): H on sp³ carbon; normally 0-5 but here at 7.27 ppm.

b) vinyl ether (CH₂=CHOCH=CH₂): H on sp² carbon normally 5-7 but here at 4.5 ppm.

c) nitrobenzene (C₆H₅NO₂): H on sp², aromatic carbon normally 7-8 but here 8.5 ppm.

Problem NMR17.

Suggest possible assignments for peaks found at the following positions in the ¹H NMR spectrum.

a) 7.4 ppm  b) 12.1 ppm  c) 3.6 ppm  d) 10.1 ppm  e) 8.2 ppm  f) 2.1 ppm  g) 5.8 ppm

Problem NMR18.

Suggest the approximate chemical shift for the circled protons in the following partial structures.
Problem NMR19.

Suggest the arrangement of neighbouring hydrogens for the following peaks in the $^1$H NMR spectrum and draw a partial structure.
Problem NMR20.

Sketch peak shapes for the circled protons in the following partial structures.
Problem NMR21.

Describe the different coupling patterns in the aromatic region of the $^1$H NMR spectra of the following isomers.

Problem NMR22.

Assign the relative number of protons at each position based on the integral lines shown.
Problem NMR23.

Suggest partial structures for the following data, given in string form.

a) 8.05 ppm (doublet, 2H) b) 3.25 ppm (septet, 1H) c) 2.65 ppm (nonet, 1H)

d) 6.55 ppm (broad singlet, 1H) e) 0.94 ppm (triplet, 3H) f) 2.33 ppm (broad singlet, 2H)

g) 8.65 ppm (singlet, 1H) h) 2.05 ppm (quartet, 2H) i) 6.21 ppm (doublet of doublets, 1H)

Problem NMR24.

Suggest complete structures from the following sets of partial structures.
Problem NMR25.

Show complete analysis of the following spectral data and propose a structure in each case.
Problem NMR26.

Sketch the expected $^1$H spectrum for each of the following structures.
Problem NMR27.

Draw what the NMR spectrum of ethylbenzene, CH$_3$CH$_2$C$_6$H$_5$, would look like if it was contaminated with an equal amount of tert-butyl methyl ether, (CH$_3$)$_3$COCH$_3$.

Problem NMR28.

The following NMR spectrum, of the aldehyde shown, is contaminated with another isomer.

1. Identify the peaks corresponding to each isomer.
2. Identify which peaks correspond to which proton in each isomer.
3. Identify the ratio of isomers in the sample.
Contributors

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