1. A proton NMR spectrum is observed to contain following the pattern below; what do you conclude?
   A. This must be a quartet that is part of an ethyl group.
   B. This must be a mono-substituted benzene.
   C. This must be an ortho-disubstituted benzene.
   D. This must be a meta-disubstituted benzene.
   E. This must be a para-disubstituted benzene.

2. The pattern in the accompanying spectrum is immediately recognizable as what structural fragment? Assume that groups X and Y do not have protons that would affect the splitting patterns.

3. Which statement about proton NMR is not true?
   A. The proton NMR spectrum generally indicates the number of different types of protons.
   B. The spectrum gives some indication of the chemical environment in which each type of proton resides.
   C. The spectrum can be integrated to give the relative ratios of each type of proton.
   D. Spin-spin splitting in the spectrum gives information about protons immediately adjacent to a given type of proton.
   E. All these statements are true.

4. Which of the following statements about carbon NMR is not true?
   A. Only the 1.1% of $^{13}$C present in organic molecules, and not the 98.9% of $^{12}$C, is observable by NMR.
   B. Carbon-carbon coupling in the spectrum gives information about adjacent carbons.
   C. Carbon NMR spectra exhibit much lower sensitivity than do $^1$H NMR spectra.
   D. With proton-decoupling, carbon spectra exhibit a single peak for each type of carbon.
   E. Carbon chemical shifts cover a much wider range than do proton NMR spectra.

5. The molecule shown will display how many triplets in its proton-coupled $^{13}$C-NMR spectrum?
   A. zero
   B. one
   C. three
   D. five
   E. none of the above
6. Which of the following molecules most likely generated the accompanying 1H-NMR spectrum?

7. Which of the following molecules most likely generated the accompanying 1H-NMR spectrum?
8. Which of the following compounds most likely generated this $^1$H-NMR data?

$$\delta 7.9 \text{ (d, 2H)}, 7.2 \text{ (d, 2H)}, 4.1 \text{ (q, 2H)},$$
$$2.7 \text{ (septet, 1H)}, 1.6 \text{ (d, 6H)}, 1.2 \text{ (t, 3H)}$$

A.  
B.  
C.  
D.  
E.  

9. The accompanying $^1$H NMR spectrum would correspond to which of the following molecules?

- A.  
- B.  
- C.  
- D.  
- E.  

10. Which of the following structures would give seven singlets (not counting TMS) in the proton-decoupled $^{13}$C-NMR spectrum?

- A.  
- B.  
- C.  
- D.  
- E.  


11. The pattern in the accompanying spectrum is immediately recognizable as what structural fragment? Assume that groups X and Y do not have protons that would affect the splitting patterns.

![Spectrum with structural fragments]

A.  
B.  
C.  
D.  
E.  

12. The accompanying $^1$H NMR spectrum would correspond to which of the following molecules?

![NMR spectra with molecular structures]

A.  
B.  
C.  
D.  
E.  

13. How many $^1$H NMR signals would the following compound give?

\[
\text{CICH}_2\text{CHCH}_3
\]

A. 1  
B. 2  
C. 3  
D. 4  
E. 5
14. The accompanying $^1$H NMR spectrum would correspond to which of the following molecules?

A. 

B. 

C. 

D. 

E. 

15. Which of the following aromatic compounds most likely generated the accompanying $^1$H-NMR spectrum?

A. 

B. 

C. 

D. 

E. 

H$_3$CO
16. Which of the following compounds most likely generated the accompanying $^1$NMR-spectrum?

![NMR Spectrum](image)

17. How many signals would you expect to find in the $^1$H NMR spectrum of CH$_2$OCH$_2$CH$_2$OCH$_3$?

A. 1    B. 2    C. 3    D. 4    E. 5

18. How many $^1$H NMR signals would cis-1,2-dichlorocyclopropane give?

A. 1    B. 2    C. 3    D. 4    E. 5

19. The $^1$H NMR spectrum of which of the compounds below, all of formula C$_7$H$_{12}$O$_2$, would consist of two singlets only?

A. I    B. II    C. III    D. IV    E. V

20. The $^1$H NMR spectrum of which of these compounds would consist of a triplet, singlet and quartet only?

A. 2-chloro-4-methylpentane    B. 3-chloro-2-methylpentane
C. 3-chloropentane    D. 1-chloro-2,2-dimethylbutane
E. 3-chloro-3-methylpentane

21. In the structure shown, H$_a$, H$_b$, and H$_c$ are classified as:

A. homotopic protons.
B. vicinal protons.
C. enantiotopic protons.
D. diastereotopic protons.
E. isomeric protons.
22. In the structure shown, H_a and H_b are classified as:
   A. homotopic protons.
   B. vicinal protons.
   C. enantiotopic protons.
   D. diastereotopic protons.
   E. isomeric protons.

23. A compound with the molecular formula C_6H_{15}N gave the following ^1H NMR spectrum: triplet, δ 0.90; quartet, δ 2.4
There were no other signals. The most likely structure for the compound is:

24. A compound C_5H_{10}O gave the following spectral data:

<table>
<thead>
<tr>
<th>^1H NMR spectrum</th>
<th>IR spectrum</th>
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<tr>
<td>doublet, δ 1.10</td>
<td>strong peak</td>
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<tr>
<td>singlet, δ 2.10</td>
<td>near 1720 cm^{-1}</td>
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<td>septet, δ 2.50</td>
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Which is a reasonable structure for the compound?

25. A compound C_4H_9Br gave the following ^1H NMR spectrum: multiplet, δ 4.1 (1H); multiplet, δ 1.8; doublet, δ 1.7; triplet, δ 1.0 (3H)

Which is a reasonable structure for the compound?

26. How many ^13C signals would 1,2-dimethylbenzene give?

27. The C_7 compound which gives 3 signals in the broadband proton-decoupled ^13C spectrum could be:

   A. heptane   B. 2-methylhexane
   C. 3,3-dimethylpentane   D. 2,4-dimethylpentane
   E. 2,2,3-trimethylbutane
28. Consider the expected splitting of signal “b” in the \(^1\text{H}\) NMR spectrum of 1-methoxy-2-methylpropane, shown below. Presuming that \(J_{ab}\) is sufficiently different from \(J_{bc}\) and that the instrument has sufficient resolving power, what is the theoretical multiplicity of signal “b”?
   A. 8  
   B. 9  
   C. 12  
   D. 21  
   E. 24

29. What is the theoretical multiplicity of the C-2 proton signal in the \(^1\text{H}\) NMR spectrum of 2-hydroxymethyl-1,3-propanediol, shown below?
   A. 1  
   B. 6  
   C. 7  
   D. 8  
   E. 9

30. An organic compound absorbs strongly in the IR at 1687 cm\(^{-1}\). Its \(^1\text{H}\) NMR spectrum consists of two signals, a singlet at 2.1 ppm and a multiplet centered at 7.1 ppm. Its mass spectrum shows significant peaks at \(m/z\) 120, \(m/z\) 105 and \(m/z\) 77. This information is consistent with which of the following structures?
   A. I  
   B. II  
   C. III  
   D. IV  
   E. V

31. Consider the expected \(^1\text{H}\) NMR spectrum of 1,1,3,3-tetramethylcyclopentane. Which of the following is likely to be observed?
   A. 7 signals: all singlets  
   B. 7 signals: 4 singlets, 3 doublets  
   C. 3 signals: all singlets  
   D. 3 signals: one singlet, 2 doublets  
   E. 3 signals: two singlets, one doublet

32. Consider the expected \(^1\text{H}\) NMR spectrum of 2,4-dimethyl-1,4-pentadiene. Which of the following is likely to be observed?
   A. 7 signals: all singlets  
   B. 4 signals: all singlets  
   C. 3 signals: all singlets  
   D. 3 signals: one singlet, 2 doublets  
   E. 4 signals: two singlets, two doublets

33. Consider the \(^1\text{H}\) NMR spectrum of very pure 1-propanol. Assuming the maximum multiplicity of signals and non-superposition of peaks, what is the expected signal splitting pattern for each signal, in the order (a, b, c, d) ?
   A. 3, 6, 4, 1  
   B. 3, 6, 4, 3  
   C. 3, 12, 3, 1  
   D. 3, 12, 3, 3  
   E. 3, 12, 6, 3
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