

1. An oxygen-containing compound which shows no IR absorption at 1630-1780  $\text{cm}^{-1}$  or at 3200-3550  $\text{cm}^{-1}$  is likely to be what type of compound?

- A) An alcohol
- B) A carboxylic acid
- C) An ether
- D) A ketone
- E) An aldehyde

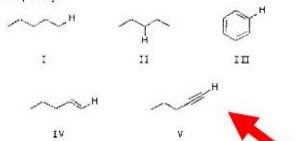
2. The IR stretching frequency occurs at the lowest frequency for which of these bonds?

- A) C-H
- B) C-O
- C) C-Br
- D) C-N
- E) C-F

3. An anticipated IR absorption band may not be observed because:

- A) it occurs outside the range of the instrument used.
- B) no change occurs in the dipole moment during the vibration.
- C) the absorption band is eclipsed by another.
- D) the intensity is so weak that it cannot be differentiated from instrument noise.
- E) All of these

4. The IR absorption due to the stretching of which of these carbon-hydrogen bonds occurs at the highest frequency?



- A) I
- B) II
- C) III
- D) IV
- E) V

5. An organic compound absorbs strongly in the IR at 1687  $\text{cm}^{-1}$ . On oxidation it is converted to benzoic acid. 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)  $\text{C}_6\text{H}_5\text{C}(=\text{O})\text{CH}_3$
- B)  $\text{C}_6\text{H}_5\text{CH}_2\text{C}(=\text{O})\text{H}$
- C)  $\text{p-CH}_3\text{C}_6\text{H}_4\text{C}(=\text{O})\text{H}$
- D)  $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{CH}_3$
- E)  $\text{C}_6\text{H}_5\text{CH}(\text{Cl})\text{CH}_3$

6. The data below from the molecular ion region of the mass spectrum of a halogen-containing compound are consistent with the presence of what halogen(s) in the original compound?

$M^+$	intensity
$M^+$	51.0
$M^+ + 2$	100.0
$M^+ + 4$	49.0

- A) One Br
- B) One Cl
- C) One Br and one Cl
- D) Two Br
- E) Two Cl

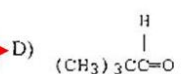
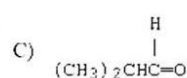
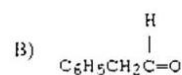
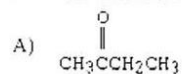
7. Select the structure of a compound  $\text{C}_6\text{H}_{14}$  with a base peak at  $m/z$  43.

- A)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- B)  $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3$
- C)  $(\text{CH}_3)_3\text{CCH}_2\text{CH}_3$
- D)  $(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)_2$
- E) None of these

11. A bromodichlorobenzene which gives four signals in the broadband proton-decoupled  $^{13}\text{C}$  spectrum could be:

- A) 2-Bromo-1,3-dichlorobenzene  
B) 2-Bromo-1,4-dichlorobenzene  
C) 3-Bromo-1,2-dichlorobenzene  
D) 4-Bromo-1,2-dichlorobenzene  
E) 4-Bromo-1,3-dichlorobenzene

12. A downfield ( $\delta$  9-10) singlet is observed in the  $^1\text{H}$  NMR spectrum of:

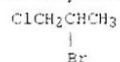


**This is the correct answer, an earlier slideshow showed C) as the answer**

13. A compound  $\text{C}_5\text{H}_{11}\text{Cl}$  which exhibits only two singlets in the  $^1\text{H}$  NMR spectrum must be:

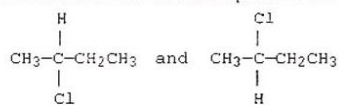
- A) 1-Chloropentane  
B) 1-Chloro-2,2-dimethylpropane  
C) 1-Chloro-2-methylbutane  
D) 3-Chloropentane  
E) 1-Chloro-3-methylbutane

14. How many  $^1\text{H}$  NMR signals would the following compound give?



- A) 1  
B) 2  
C) 3  
 D) 4  
E) 5

15. Distinction between the methine protons in the compounds



should be possible in the  $^1\text{H}$  NMR spectra if:

- A) a very high field instrument is used.  
B) the spectra are determined in a chiral solvent.  
C) a long scan time is used for each compound.  
D) a high amplitude setting is employed.  
E) Distinction between the enantiomers is impossible.

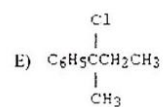
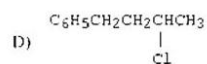
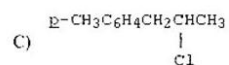
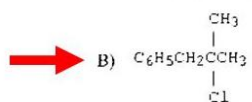
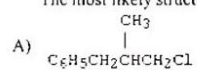
16. A compound with the molecular formula  $C_{10}H_{13}Cl$  gave the following  $^1H$  NMR spectrum:

singlet,  $\delta$  1.6

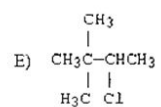
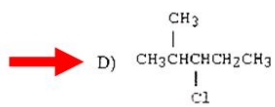
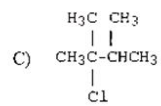
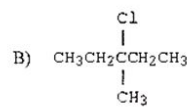
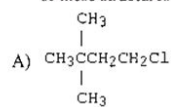
singlet,  $\delta$  3.1

multiplet,  $\delta$  7.2 (5H)

The most likely structure for the compound is:



17. The broadband proton-decoupled  $^{13}C$  NMR spectrum of a hexyl chloride exhibits five signals. Which of these structures could be the correct one for the compound?



18. How many  $^{13}\text{C}$  signals would 1,3-dichlorobenzene give?

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5



19. In the structure shown,  $\text{H}_a$  and  $\text{H}_c$  are classified as:



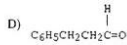
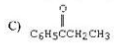
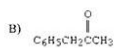
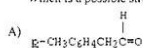
- A) homotopic protons.
- B) vicinal protons.
- C) enantiotopic protons.
- D) diastereotopic protons.
- E) isomeric protons.



20. A compound, X,  $\text{C}_8\text{H}_{10}\text{O}$ , gives a strong IR absorption peak at  $1690\text{ cm}^{-1}$  and gives the following  $^1\text{H}$  NMR spectrum.

Triplet,	$\delta$ 1.2
Quartet,	$\delta$ 3.0
Multiplet,	$\delta$ 7.7

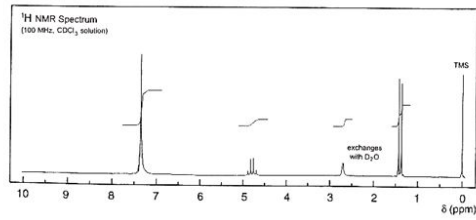
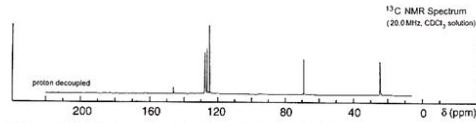
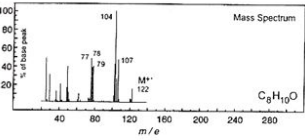
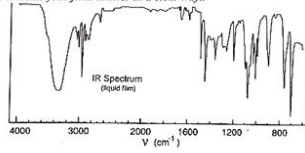
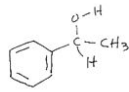
Which is a possible structure for X?



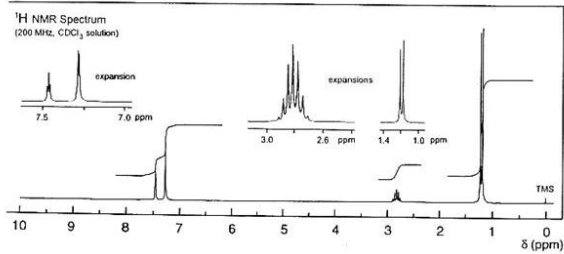
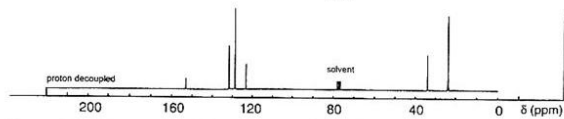
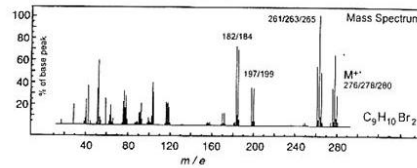
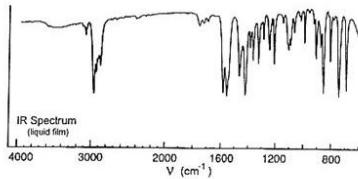
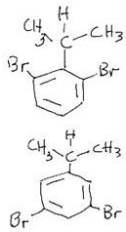
- 21. 2,3-Dimethyl-2-butene shows a strong band at about  $1635\text{ cm}^{-1}$
- 22.  $\text{C}_6\text{H}_5\text{C}(=\text{O})\text{CH}_3$  shows a  $\text{C}=\text{O}$  stretch at larger wave numbers than  $\text{C}_6\text{H}_5\text{CH}_2\text{C}(=\text{O})\text{CH}_3$ .
- 23. When a compound suspected as a component in a mixture is added to the mixture and subjected to gas chromatography, an enhanced, sharp peak is very good evidence of the identity of the unknown.
- 24. The proton-coupled  $^{13}\text{C}$  spectrum of the methyl carbon in 1-propanol is a quartet.
- 25. Dr. Paul Lauterbur won the 1953 Nobel Prize for the discovery of MRI.
- 26. The number of decoupled  $^{13}\text{C}$  signals for cis-1,3-dichlorocyclohexane is 4.
- 27. A  $\text{F}^{19}$  spectrum of  $(\text{CF}_3)_3\text{P}$  would show up as a triplet.
- 28. The  $\text{CH}_2$  protons in phenylalanine ( $\text{C}_6\text{H}_5\text{CH}_2\text{CH}(\text{NH}_2)\text{CO}_2\text{H}$ ) are enantiotopic.
- 29. The parent ion of a molecule with 2 bromine atoms will show peaks looking like a 1:2:1 triplet.
- 30. The maximum number of peaks for the  $(\text{CH}_2)$  carbon in  $\text{C}_6\text{H}_5\text{CHCl}(\text{CH}_2)\text{CH}_3$  could be as many as 32; consider only H-H splitting.
- 31. A molecular mass computed to 4 decimal places usually corresponds to at least 20 *unique* formulas.
- 32. The coupling constants for the hydrogen atoms in E and Z-2,3-dibromo-2-butene are nearly equal.
- 33. The first proton NMR spectrum of an organic compound was for ethanol showing splitting of the ethyl group.
- 34. One of the main detectors for gas chromatography is based on the thermal conductivity of the gases in the detector.
- 35. Mikhael Tswett is credited in inventing column chromatography in the 1950s.

1. 45 marks Determine the structure in each of the following three examples. In each case give a brief rationale for the assignments. Be very sure to indicate your final answer in a clear way.

a. (15 marks)



b. (15 marks)



c. (15 marks)

