CHEM311
FALL 2005
Practice Exam #3

Instructions: This is a multiple choice / short answer practice exam. For the multiple-choice questions, there may be more than one correct answer. If so, then circle as many answers as you believe to be correct. You will get 3 pts for each correct response and –1 for each wrong response. If there is a choice of “other”, and you choose “other”, you MUST provide a correct alternative answer on the line provided in order to get the question right. Only choose “other” if there are no correct answers present. The short answer questions are worth 5 to 20 points each. Where I have asked for you to draw a structure or mechanism, be very precise with your arrows and such…don’t make me guess as to what you meant.

You may only use a pen or pencil, big eraser, and a molecular model set to take this exam. You have 60 minutes to complete this exam. Your signature above indicates that you have taken this exam in accordance with the University Honor Code. Good luck!

1) Infrared spectrometry…
   a. …is for the most part, qualitative.
   b. …can tell you how functional groups are arranged.
   c. …can tell you how many C=O bonds there are in a molecule.
   d. …can tell you the molecular formula of a compound.
   e. other: __________________________________________________________________

2) Proton NMR…
   a. …tells you about the local magnetic environment of any particular proton
   b. …tells you how many carbons are in the molecule.
   c. …can tell you how the different pieces of the molecule are arranged
   d. …is too confusing to be taught at the undergraduate level.
   e. other: __________________________________________________________________

3) What is the function of the magnet in NMR?
   a. It limits the nuclear spin to certain allowed spin states.
   b. It allows random orientation of nuclear magnetic moments.
   c. It causes the nucleus to spin.
   d. It holds the sample in place.
   e. other: __________________________________________________________________

4) What is the source of shielding in NMR?
   a. protons
   b. photons
   c. neutrons
   d. electrons
   e. other: __________________________________________________________________

5) For each of the compounds below tell how many signals you would expect the molecule to have in its normal, broadband decoupled $^{13}$C NMR spectra.

   a.) 2
   
   b.) 6

   ![Structure A](image1)
   ![Structure B](image2)
6) Which of the following is true of NMR spectra?
   a. Electronegative elements "deshield" nuclei, which causes their signals to appear at lower δ values.
   b. Magnetic field strength decreases in a NMR spectrum from right to left.
   c. $^1$H and $^{13}$C NMR signals do not appear in the same spectrum because NMR's are never run on compounds that contain both $^1$H and $^{13}$C.
   d. Alkyne peaks appear upfield from alkene peaks because the ring current felt by the hydrogen of the alkyne is in the opposite direction of the applied magnetic field.
   e. other: _______________________________________________________________________

7) Which of the following compounds gives a proton NMR spectrum in which two of the signals are triplets?

   a.)  
   b.)  
   c.)  
   d.)

8) For each of the compounds below tell how many signals you would expect the molecule to have in its $^1$H NMR spectra ignoring splitting.

   a.) 2  
   b.) 5  

9) Predict the splitting patterns you would expect for the indicated protons in the molecules below.

   a.) ____________  
   b.) ____________  

   a triplet of doublets  
   a septet  

10) An unknown compound had the molecular formula C₅H₁₀O. It had five signals in its $^{13}$C NMR spectrum. One of these was in the δ 170 to 210 range while the others were all in the δ 0 to 60 range. Its IR spectrum showed absorption bands at 1725, 2715 and 2810 cm⁻¹. Which of the following compounds fits the data given for this unknown? Explain your reasoning.

   a. CH₃CH₂CH₂CH₂CO₂H  
   b. CH₃CH₂CH=CHCH₂OH  
   c. CH₂=CHCH₂OCH₂CH₃  
   d. CH₃CH₂CH₃CH₂CH=O

   The IR indicates an aldehyde functional group. Thus, the only choice is d.
11) A compound has a molecular formula of $C_6H_5BrO$. The various spectra are shown below. Determine the structure of the compound and **SHOW ALL WORK**, noting all important IR peaks and identifying all protons in the NMR.

\[ DU = \frac{((6*2)+2)-6}{2} = 4, \text{ possible benzene ring} \]

\[
\begin{array}{c}
\text{Br} \\
\text{H-O} \\
\text{aromatic C=C} \\
\text{aromatic bend}
\end{array}
\]

only substitution pattern that results in two doublets
12) A compound has the molecular formula of C₃H₅N. The various spectra are shown below. Determine the structure of the compound and **SHOW ALL WORK**, noting all important IR peaks and identifying all protons in the NMR spectrum.

**IR Peaks:**
- CH₃ next to CH₂: triplet, integration = 1.5
- CH₂ next to CH₃: quartet, integration = 1

**NMR Peaks:**
- Csp³-H
- C≡N

DU = [(3*2)+2-4]/2 = 2

\[ \equiv N \]
13) A compound has the molecular formula of C$_5$H$_{10}$O. Determine the structure of the compound and **SHOW ALL WORK**, noting all important IR peaks and identifying all protons in the NMR spectrum.

DU = $[((5*2)+2)-10]/2 = 1$

must be ketone since no aldehyde peaks in IR

NMR integration ratio is 2:3 – only accounts for 5 hydrogen, so multiply ratio by 2 gives 4:6 ratio – for a total of 10 hydrogen. Molecule contains 2 equivalent CH$_2$ groups and 2 equivalent CH$_3$ groups.
14) You are given two vials, each with an unknown organic compound in them. You are told that one contains ethyl acetate, and the other contains methyl propionate (shown below). Your job is to unambiguously identify which sample is in which vial. Convince me that you can tell which compound is in which vial by selecting ONE instrumental technique (IR or NMR) and detailing exactly how that technique can be used to absolutely identify each compound.

![Structures](structure.png)

ethyl acetate  
methyl propionate

You can only tell the difference between the two using NMR. The proton NMR for ethyl acetate will have a peak between four and five that integrates to 2 and has a quartet splitting pattern. For methyl propionate, the peak between four and five will integrate to 3 and be a singlet.