NAME _____

ID # _____

INTERPRETATION OF ORGANIC SPECTRA (4361/8361)

9:05 – 9:55 am, October 27, 2010

Exam 2

This exam is open book and open note. You are permitted to use any written materials you have brought as aids on this exam. You may also use a simple calculator. Other than this, please do not use any other electronic devices (cell phones, computers, recording devices, etc.) during the exam.

You may use pen or pencil. However, re-grades will be considered only for exams completed in pen.

Please write your answers in the boxes/spaces provided. If your answer is not in the appropriate space (say, for example, it's on the back of the page), draw us an arrow and/or note telling us where to look.

Feel free to remove the corner staple if this helps you analyze the spectra; you will have the opportunity to re-staple your exam at the end. The exam in this packet is designed to take 30 minutes to complete. You will be given 50 minutes total to finish the test. This exam contains one problem, which is split into parts. Many of these parts can be answered independently. *Do not get stuck* on one part and then assume that you will be unable to answer the rest of the question—move on. In addition, partial credit will be given for incorrect but still plausible answers, so *guess* on problems you cannot answer perfectly.

At the end of the 50 minute exam period you will be asked to return your exam to the proctor. Please do not take any part of the exam packet with you when you are done; everything will be returned to you after the exams are graded. This packet should contain 10 pages, including this one. Please check to make sure that your packet contains 10 pages before beginning your exam.

NAME _____

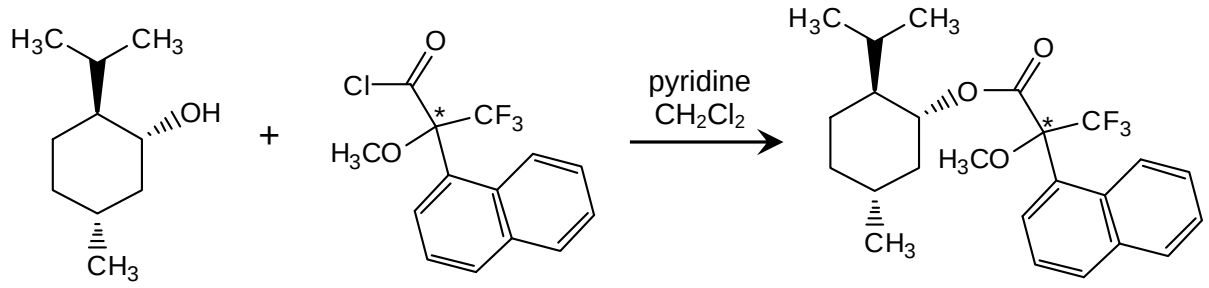
Scoring: 1. _____ / 66 4. _____ / 12

2. _____ / 6 5. _____ / 10

3. _____ / 6

Total Score: _____ / 100

Enver Izgu (Hoye group) recently completed an analysis of the methoxy(trifluoromethyl)-(1-naphthoyl)acetate (MTNA) group as an alternative chiral derivatizing agent to Mosher's MTPA group. Enver chose to first demonstrate the MTNA group on (-)-menthol. Unfortunately, because Enver was unable to separate (*R*)-MTNA chloride from (*S*)-MTNA chloride, he had to synthesize (*S*)- and (*R*)-MTNA esters of methanol as a mixture of two diastereomers, separate the diastereomers by chromatography, and analyze them by NMR to determine which was which.



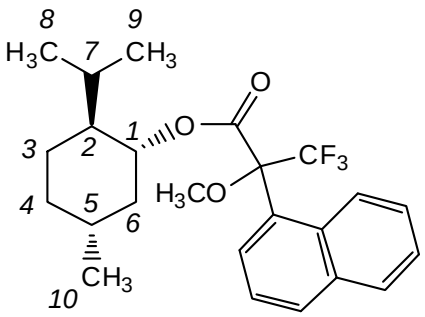
(-)-menthol

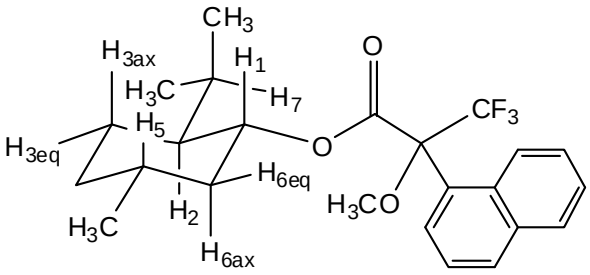
MTNA-Cl
(mixture of enantiomers)

mixture of
diastereomers

^{1}H NMR spectra of both isolated diastereomers (which I will call "diastereomer **A**" and "diastereomer **B**") are attached to the back of this exam. In addition, ^{1}H-^{1}H COSY, ^{1}H-^{13}C HMQC (full and closeup) and ^{1}H-^{13}C HMBC (closeup) of diastereomer **A** are also attached. A primary goal of the exam will be to determine which of the two diastereomers is the (*S*)-MTNA ester, and which is the (*R*)-ester.

1. In the chart on the next page, list chemical shifts for proton atoms (to within 0.05 ppm) and carbon atoms (to within 3 ppm) in diastereomer **A**. The two diagrams above the chart show (a) the standard numbering scheme for the protons and carbons in the menthol part of the molecule, and (b) the most stable chair conformation of the menthol.



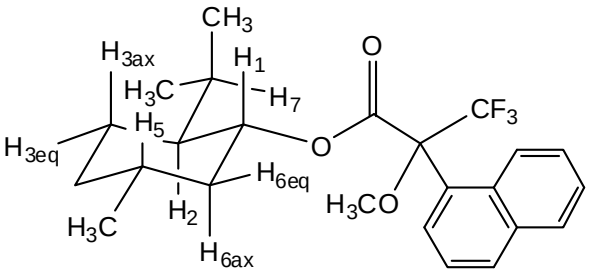


proton	δ (ppm)
$H_{[1]}$	
$H_{[2]}$	
$H_{[3eq]}$	
$H_{[3ax]}$	
$H_{[5]}$	
$H_{[6eq]}$	
$H_{[6ax]}$	
$H_{[7]}$	
$-C(H_{[8]})_3$ $-C(H_{[9]})_3$	
$-C(H_{[10]})_3$	
$-OCH_3$	

carbon	δ (ppm)
$C_{[1]}$	
$C_{[2]}$	
$C_{[3]}$	
$C_{[4]}$	
$C_{[5]}$	
$C_{[6]}$	
$C_{[7]}$	
$C_{[8]}$ $C_{[9]}$	
$C_{[10]}$	

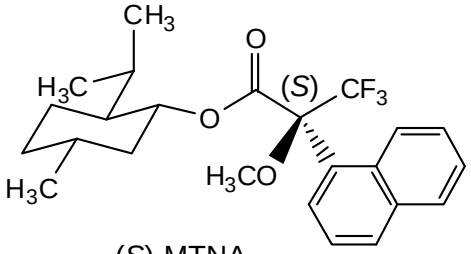
I don't think it is possible to distinguish H_8 from H_9 or C_8 from C_9. Please write your assignments for these into the combined boxes above.

2. Two crosspeaks are circled in grey on the ^{1}H-^{1}H COSY spectrum. What correlations do these crosspeaks represent? Draw each one on the structure at right as a double-headed arrow.



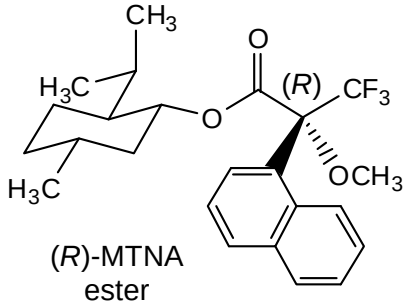
3. HMQC and HMBC are techniques for detecting heteronuclear (^{13}C-^{1}H) correlations. The HMBC spectrum lacks some ^{13}C-^{1}H correlations that are observed in the HMQC spectrum; two such cases are indicated by grey rectangles on the HMBC. Why are there no peaks at these locations?

4. Based on the attached spectra, is diastereomer **A** the



(*S*)-MTNA ester

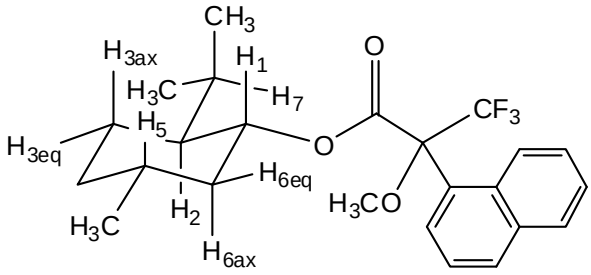
or the



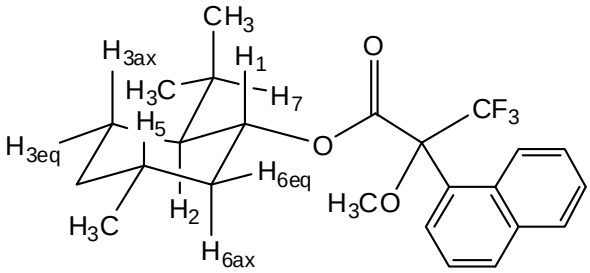
(*R*)-MTNA ester

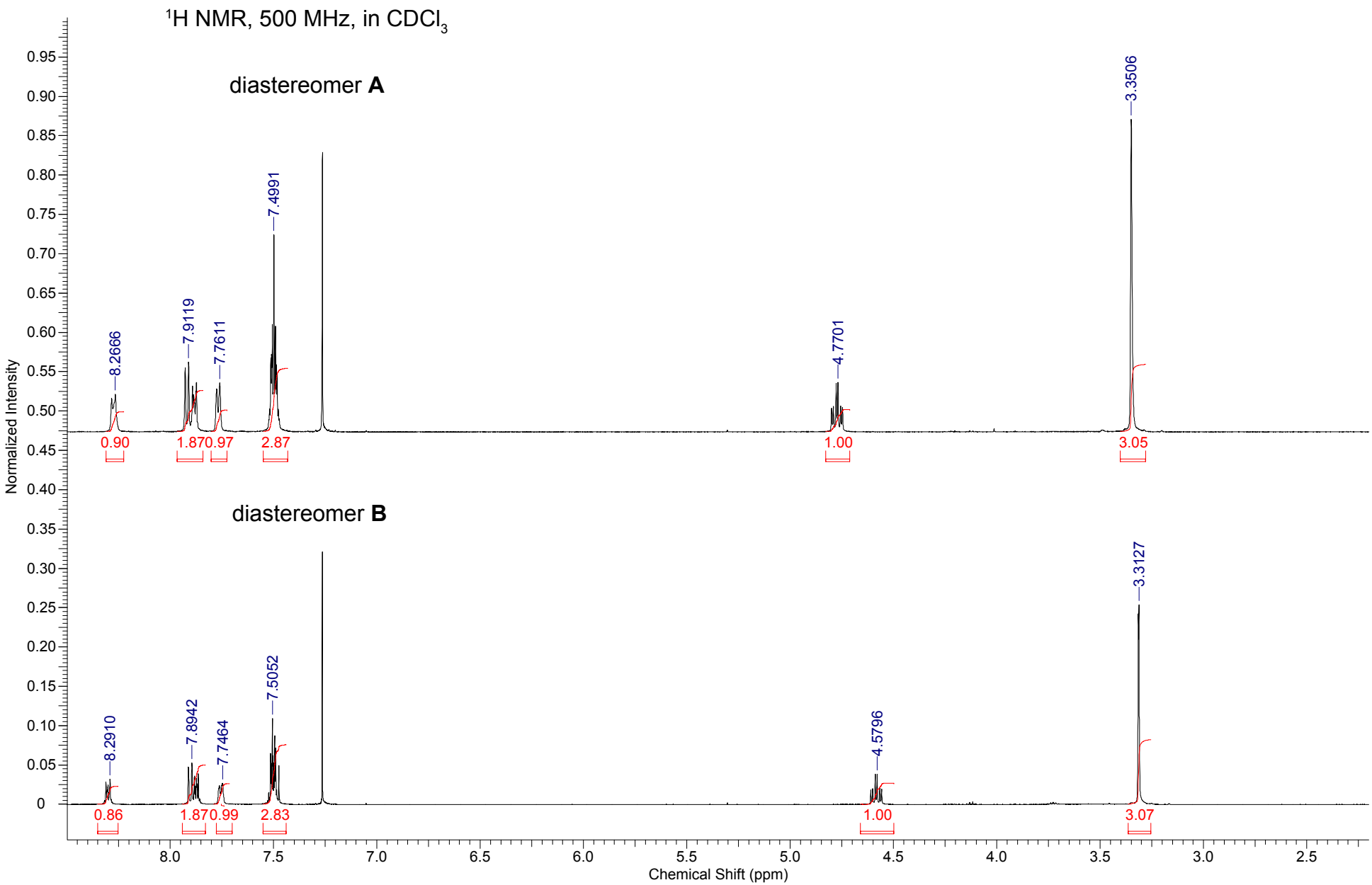
?

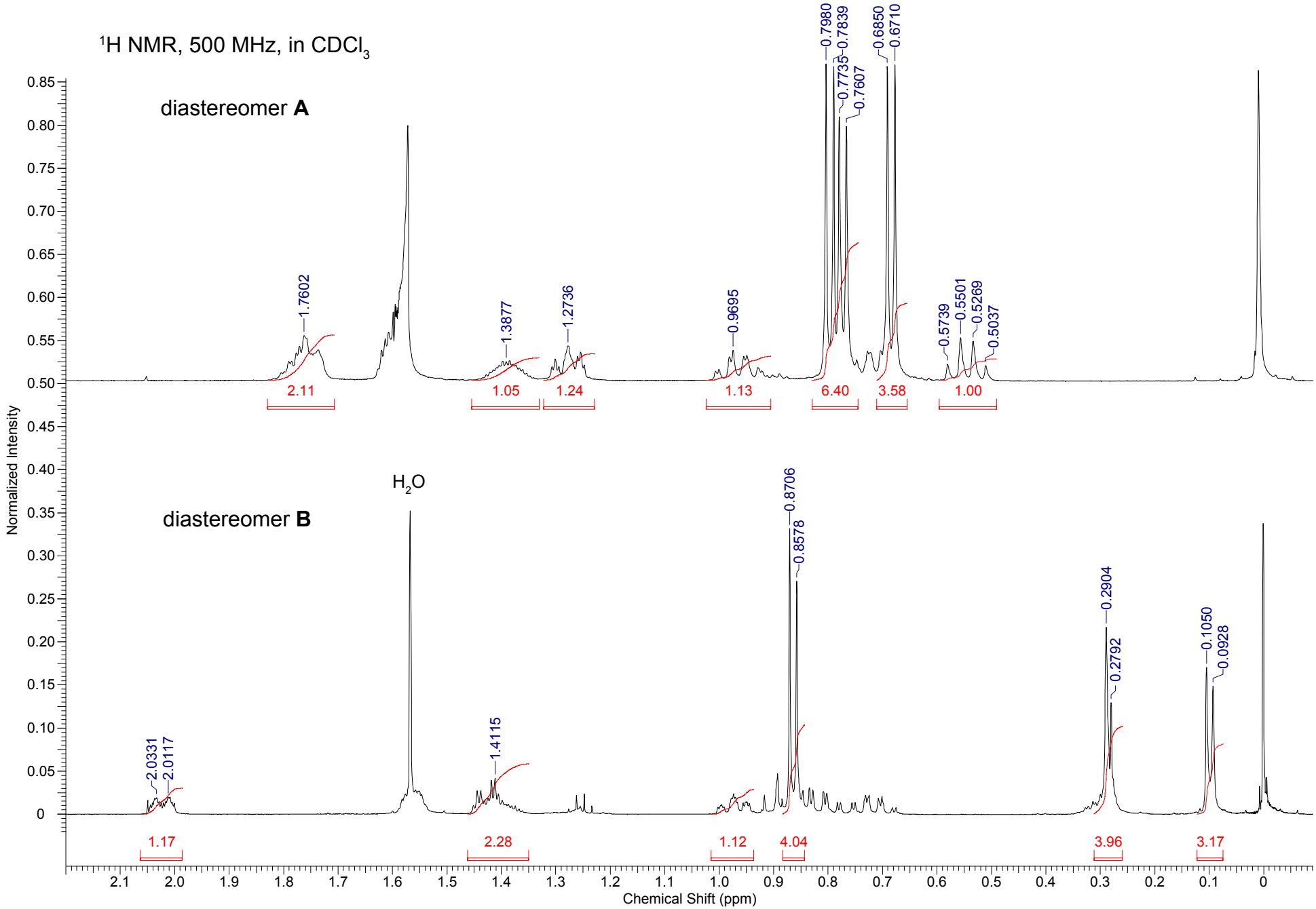
Circle one answer. Then, on the structure on the right, circle two (inequivalent) protons where you can identify whether $\delta\Delta$ (= δ_S - δ_R) is positive or negative. Next to each circle, write either "$\delta\Delta > 0$" or "$\delta\Delta < 0$".



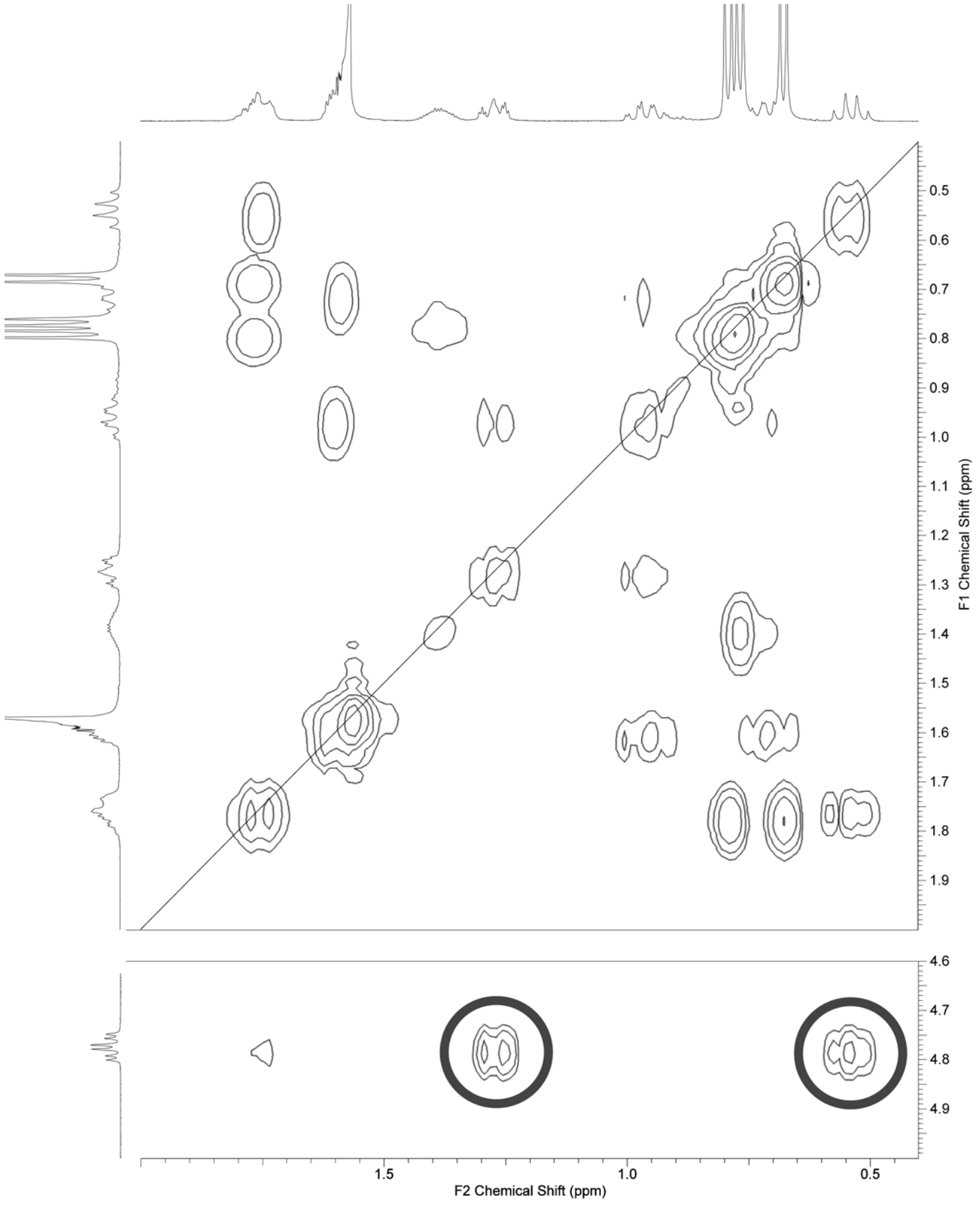
5. One way to confirm your identification of diastereomer **A** would be to perform a 1D nuclear Overhauser effect (NOE) experiment. On the structure at right, circle two different protons that you might irradiate in separate NOE experiments. Then, using single-headed arrows, illustrate one specific NOE enhancement for each circled proton which would confirm your assignment if you observed it.




^{1}H NMR, 500 MHz, in $CDCl_3$
diastereomer **A**
8.2666
7.9119
7.7611
7.4991
4.7701
3.3506
0.90
1.87
0.97
2.87
1.00
3.05
diastereomer **B**
8.2910
7.8942
7.7464
7.5052
4.5796
3.3127
0.86
1.87
0.99
2.83
1.00
3.07
Normalized Intensity
Chemical Shift (ppm)

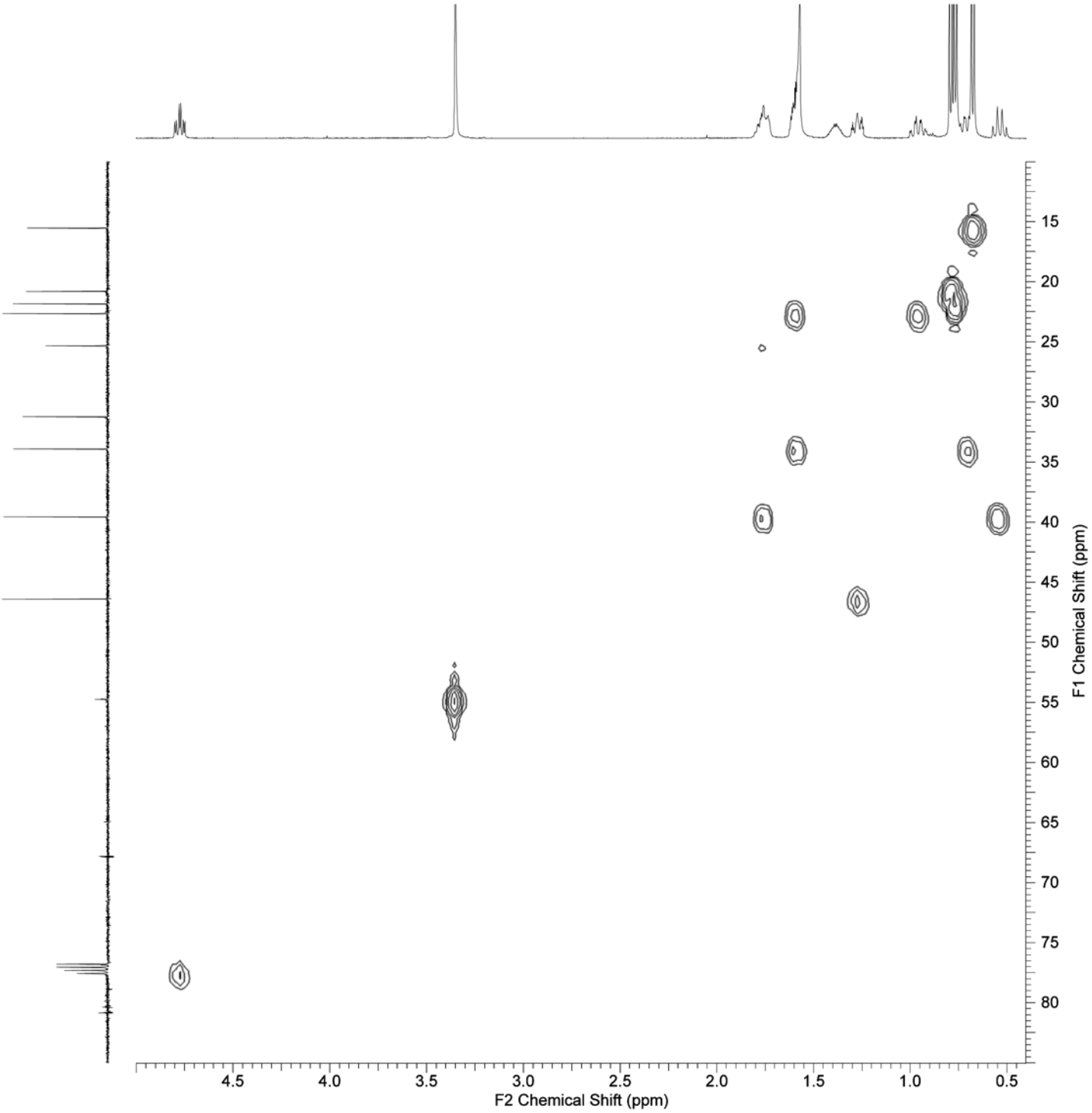

^{1}H NMR, 500 MHz, in $CDCl_3$
diastereomer **A**
diastereomer **B**
H_2O
0.7980
0.7839
0.7735
0.7607
0.6850
0.6710
1.7602
1.3877
1.2736
0.9695
0.5739
0.5501
0.5269
0.5037
2.11
1.05
1.24
1.13
6.40
3.58
1.00
0.8706
0.8578
0.2904
0.2792
0.1050
0.0928
2.0331
2.0117
1.4115
1.17
2.28
1.12
4.04
3.96
3.17
Normalized Intensity
Chemical Shift (ppm)

^{1}H-^{1}H COSY, 500 MHz, in $CDCl_3$



^{1}H-^{13}C HMQC, in $CDCl_3$

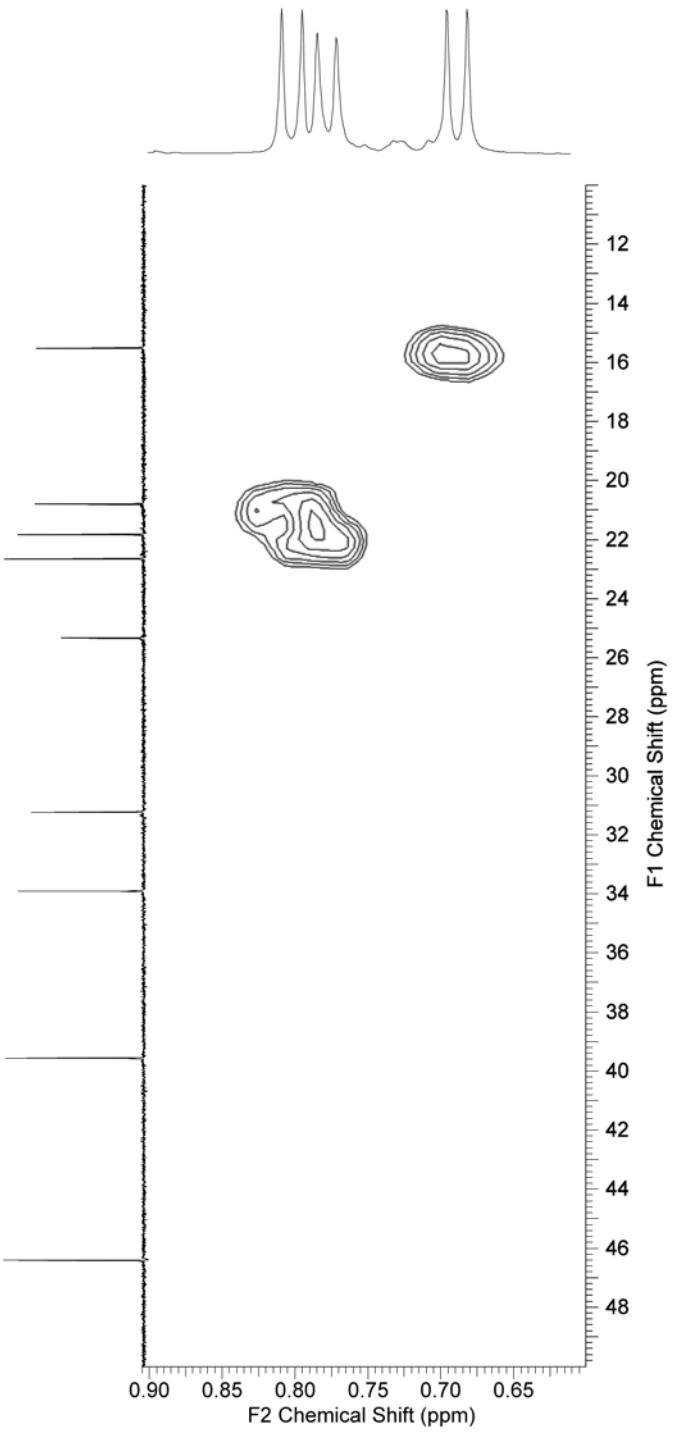
diastereomer **A**



^{1}H-^{13}C HMQC, in $CDCl_3$

diastereomer **A**

(closeup)



^{1}H-^{13}C HMBC, in $CDCl_3$

diastereomer **A**

(closeup)