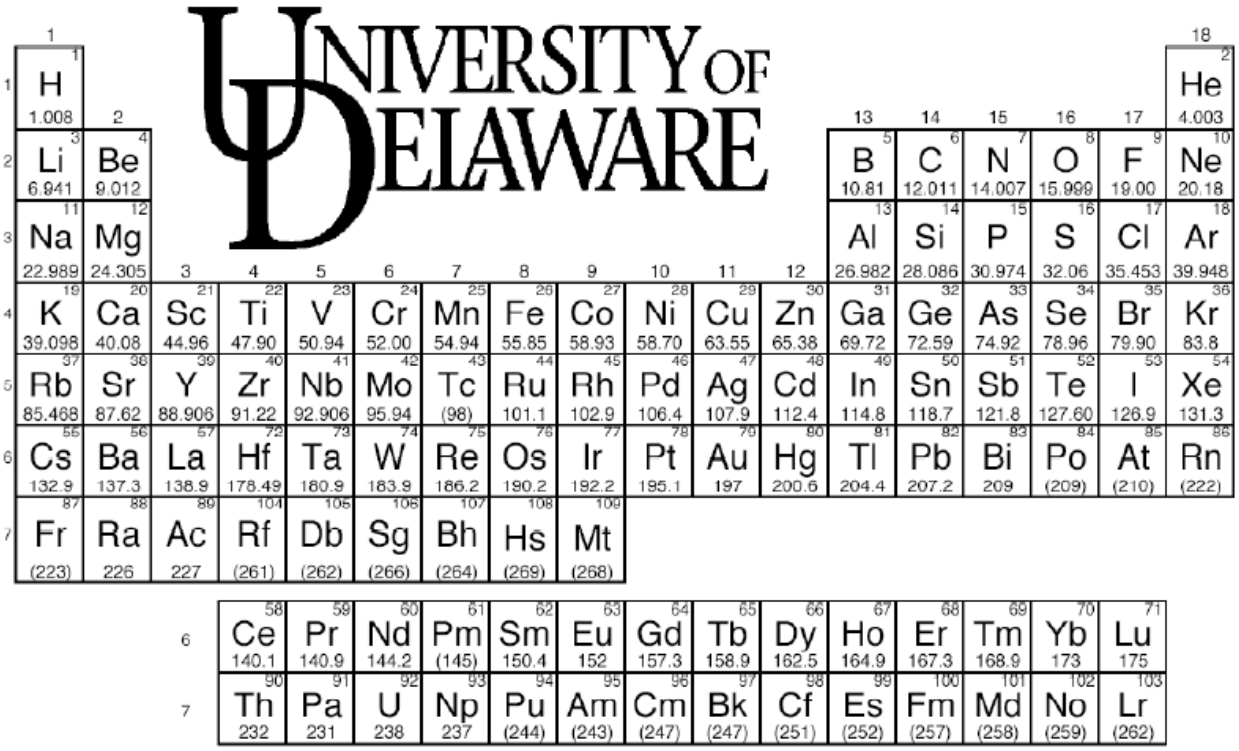
Name:_____

(Print your name clearly!)

Sametz: CHEM 322 Spring 2013

Organic Chemistry Final

All answers should be written CLEARLY in the space provided. (If it's not clear, it's wrong).

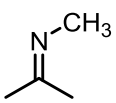


FOR QUESTIONS 9-10: read the instructions carefully regarding checking the "skip" boxes. You need to do 3 questions per page for Question 9, and 4 questions per page for #10.

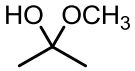
You may raise your hand to ask a question if you are unsure what a question is asking of you.

Part I: Multiple Choice (8 points)

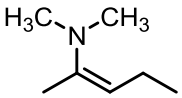
Consider the following compounds and answer questions 1-4.



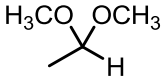
a



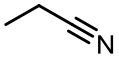
b



c



d

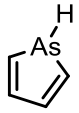


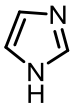
e

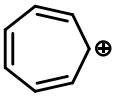
1. Which is a **hemiacetal**?	a	b	c	d	e
2. Which is an **enamine**?	a	b	c	c	d
3. Which would give an **aldehyde** upon acid hydrolysis?	a	b	c	d	e
4. Which is not stable enough to be isolated?	a	b	b	d	e

Part II: Short Answer (35 points)

5. (5 points) For each of the species below, indicate whether it is aromatic, antiaromatic, or neither.

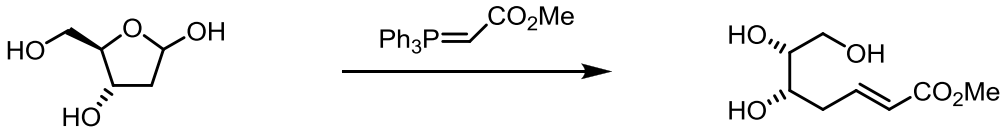






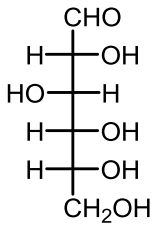
6. (8 points) Cyclic hemiacetals can react with phosphonium ylides to give alkenes. For example, the reaction below was a step in the synthesis of leukotriene B_4 reported by E.J. Corey in 1980:

Give a mechanism for this reaction. Hint: the reaction conditions are basic (but anhydrous), so you may invoke a generic base (B:) as needed. If you get stuck, you may provide a mechanism for the reaction of the ylide with a convenient carbonyl compound (e.g. benzaldehyde) instead.



7. (10 points) Choose **one** of the five reactions below. Show the product of the reaction described, and give a reasonable reaction mechanism to account for its formation. Note: this question is also testing you on nomenclature. Partial credit may be given for a reasonable mechanism and product if your reactants/reagents aren't quite correct.

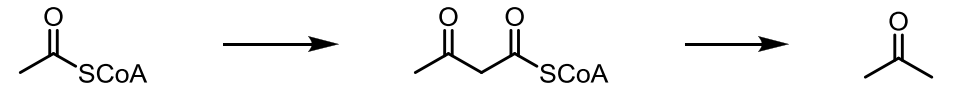
- Michael addition of cyanide to methyl propenoate
- Friedel-Crafts acylation of anisole with butanoyl chloride (the acid chloride derived from butanoic acid)
- Acid-catalyzed hydrolysis of ethyl acetoacetate followed by decarboxylation
- Haloform reaction of acetophenone (phenylpropanone) with iodine
- Claisen-Schmidt condensation (in base) of equimolar amounts of acetone and benzaldehyde
- Reaction of D-glucopyranose with acidic methanol to give a methyl glycoside



D-glucose

8. (12 points) When fasting or starving, your body will convert acetyl-CoA into “ketone bodies” such as acetone. This can also happen in diabetics that don’t carefully monitor their insulin, and the resulting condition (ketoacidosis) can be fatal.

The actual biochemical pathway for this conversion is less direct than that shown below (HMG CoA is involved). However, provide a plausible mechanism for the sequence of reactions below. You can use some generic base (B:) for the conversion of acetyl-CoA to acetoacetyl-CoA in the first step, and H_3O^+/H_2O for the conversion of acetyl-CoA to acetone.



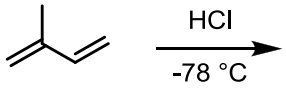
Acetyl-CoA **Acetoacetyl-CoA** **acetone**

Part IV: Reactions (72 points)

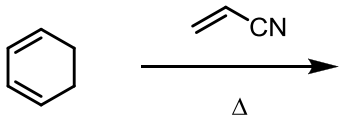
9. (48 points) Give the major organic product(s) for the following reactions. **On each page (Parts A through D), you may check TWO questions to skip and DO THE REMAINING THREE.**

Part A

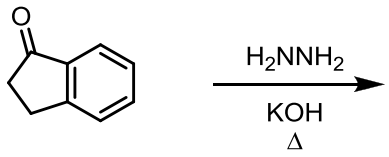
a) ❑SKIP this one



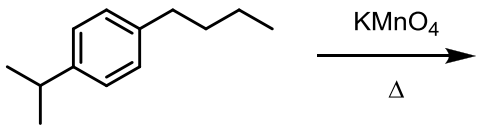
b) ❑SKIP this one



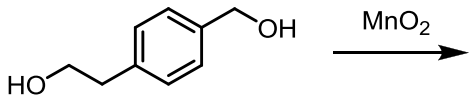
c) ❑SKIP this one



d) ❑SKIP this one

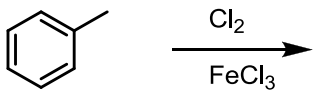


e) ❑SKIP this one

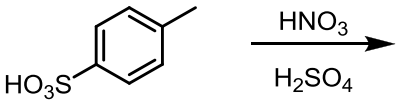


Part B

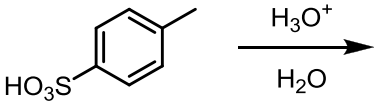
f) ❑SKIP this one



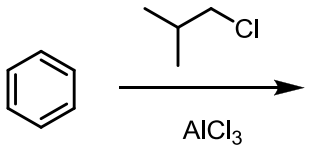
g) ❑SKIP this one



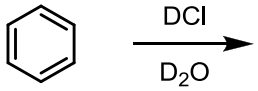
h) ❑SKIP this one



i) ❑SKIP this one

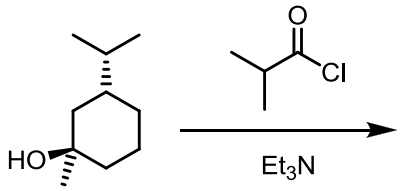


j) ❑SKIP this one

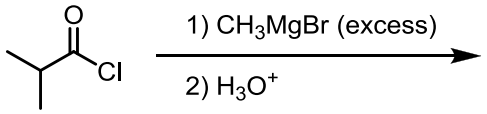


Part C

k) ❑SKIP this one



l) ❑SKIP this one



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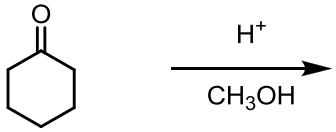
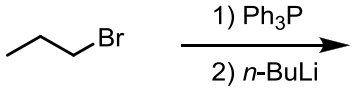
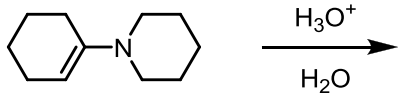


n) ❑SKIP this one

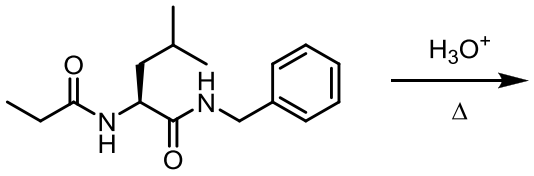


o) ❑SKIP this one

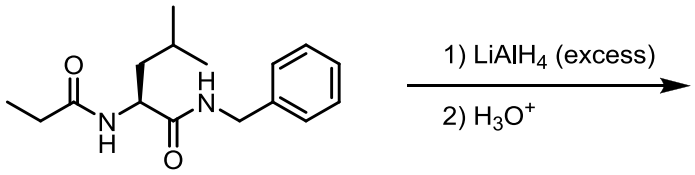


Part D

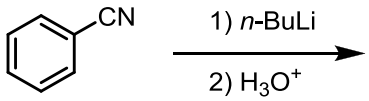
p) ❑SKIP this one



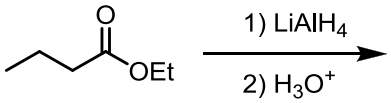
q) ❑SKIP this one



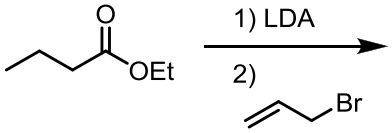
r) ❑SKIP this one



s) ❑SKIP this one



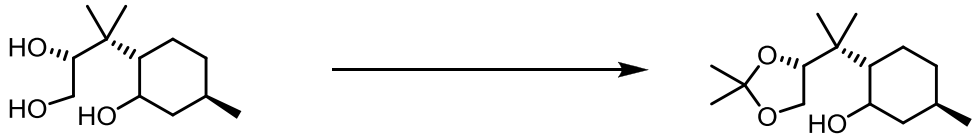
t) ❑SKIP this one



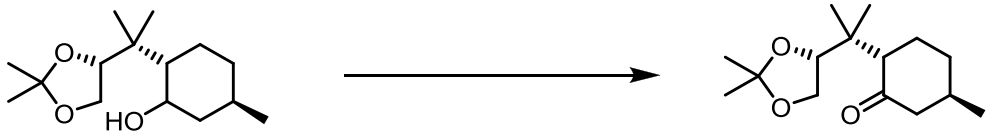
10. (24 points) Provide reagents that would effect the following transformations. **On each page (Parts A and B), you may check ONE question to skip and DO THE REMAINING FOUR.**

Part A

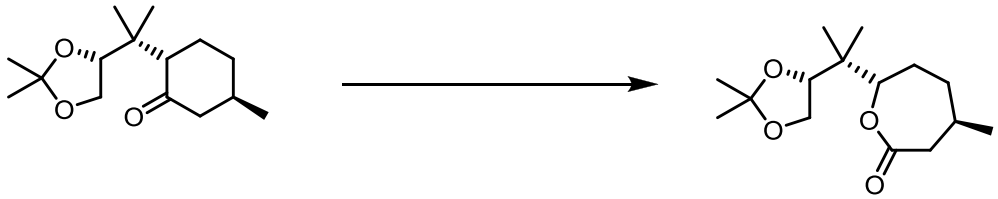
a) ❑SKIP this one



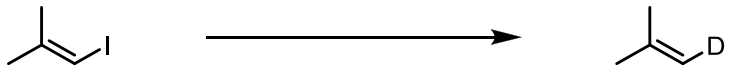
b) ❑SKIP this one



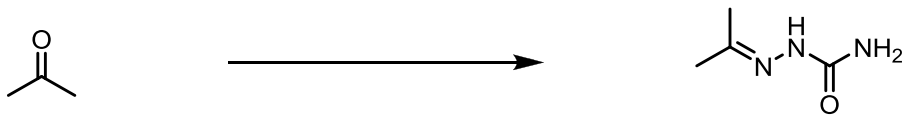
c) ❑SKIP this one



d) ❑SKIP this one

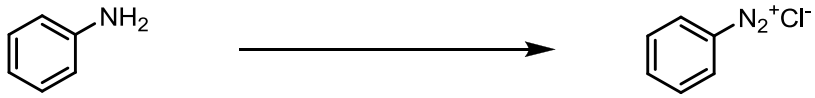


e) ❑SKIP this one

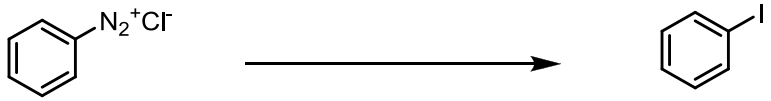


Part D

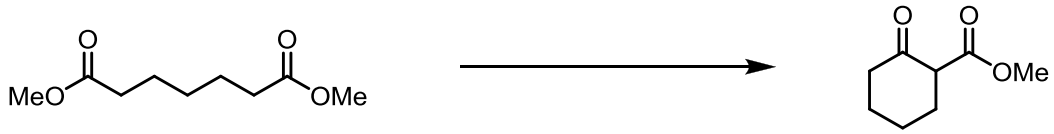
f) ❑SKIP this one



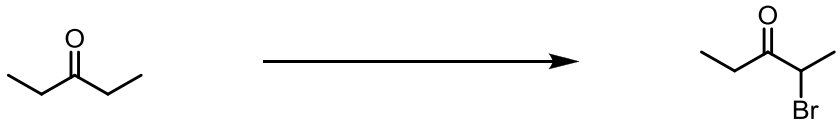
g) ❑SKIP this one



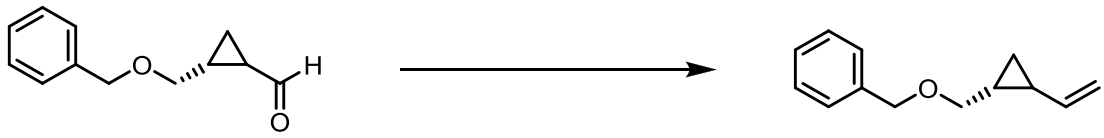
h) ❑SKIP this one



i) ❑SKIP this one



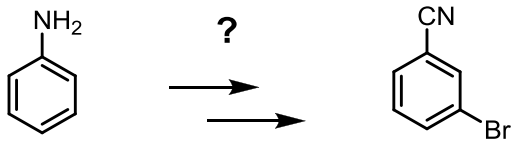
j) ❑SKIP this one



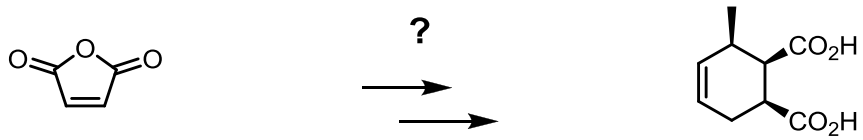
Part V Multistep Synthesis (20 points)

11. (8 points) Multistep synthesis Propose an efficient synthesis for **ONE** of the two compounds below on the right from the starting material on its left. Please draw the structures of the intermediate reaction products. (Just the product, not the mechanism) **CLEARLY** indicate which of the two you wish to be graded; if it's not clear to the grader, they will choose one to grade.

a)

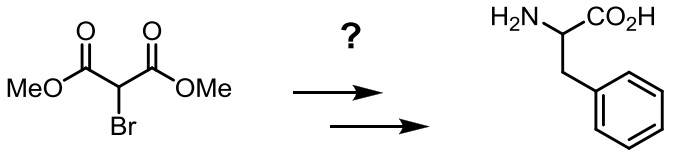


b)



12. (12 points) Choose **ONE** of the following two synthesis problems, and provide a sequence of reactions that will synthesize the compound on the right from the starting material on the left. **Draw out the structures of the intermediate reaction products**. If you show work on both, **CLEARLY** indicate which of the two you wish to be graded; if it's not clear to the grader, they will choose one to grade.

a)



b)

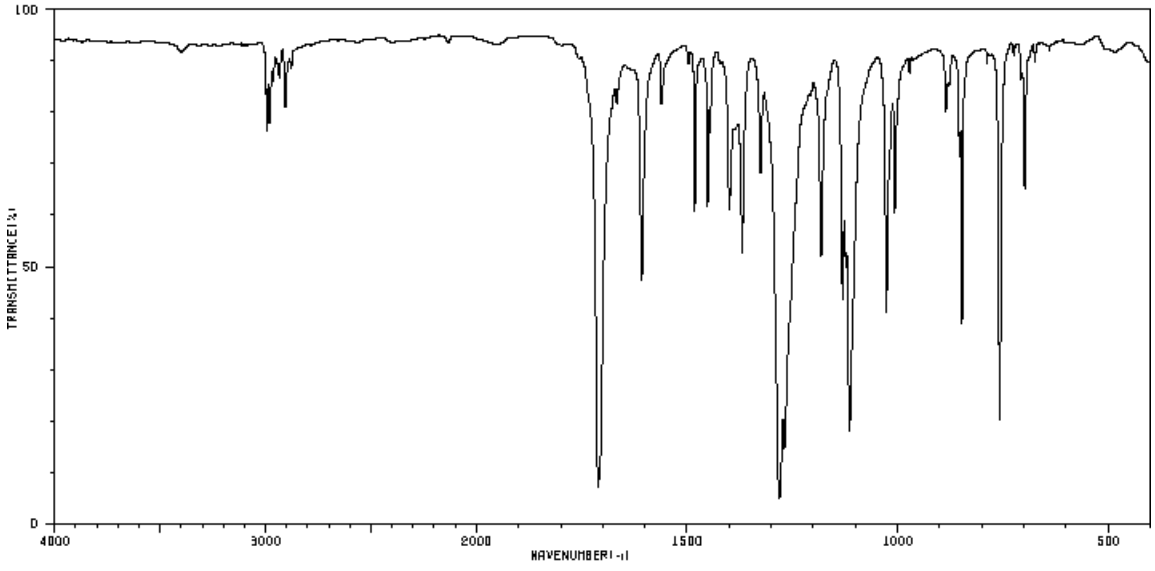
Part VI: Spectroscopic Analysis of an Unknown Compound (15 points)

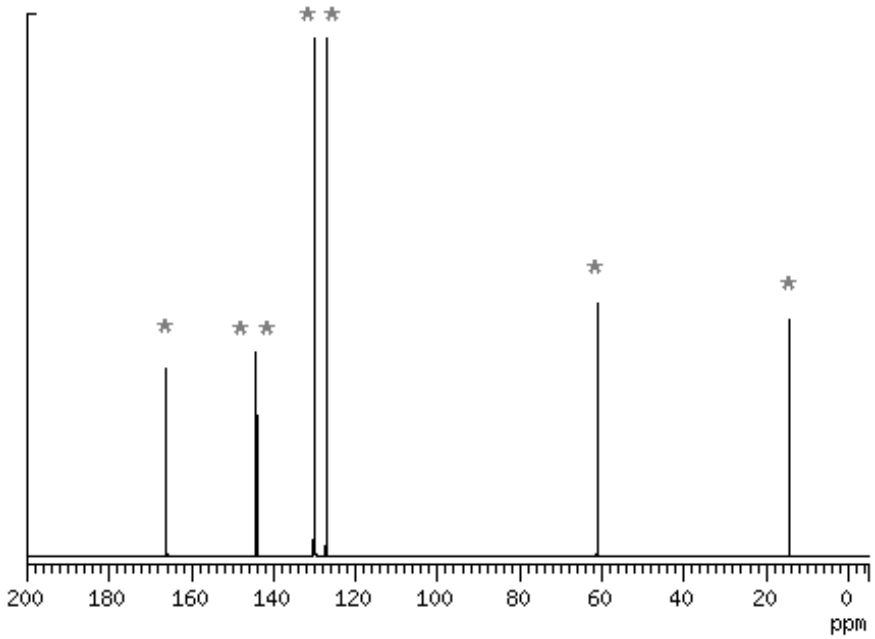
13. The ^{1}H and ^{13}C NMR spectra for a compound with the formula $C_{18}H_{18}O_4$ are shown on the next page; the IR spectrum is shown below On the ^{1}H NMR spectrum, the integrations for the signals ("3H", etc.) are shown above them. On the ^{13}C NMR spectrum on the next page, the signals that correlate with carbons in the unknown are marked with asterisks (*). Note that there are two signals (and thus two asterisks) at ca. 144 ppm—the two signals are so close in chemical shift that they blur together into what looks like one peak. The IR spectrum for the compound is shown below.

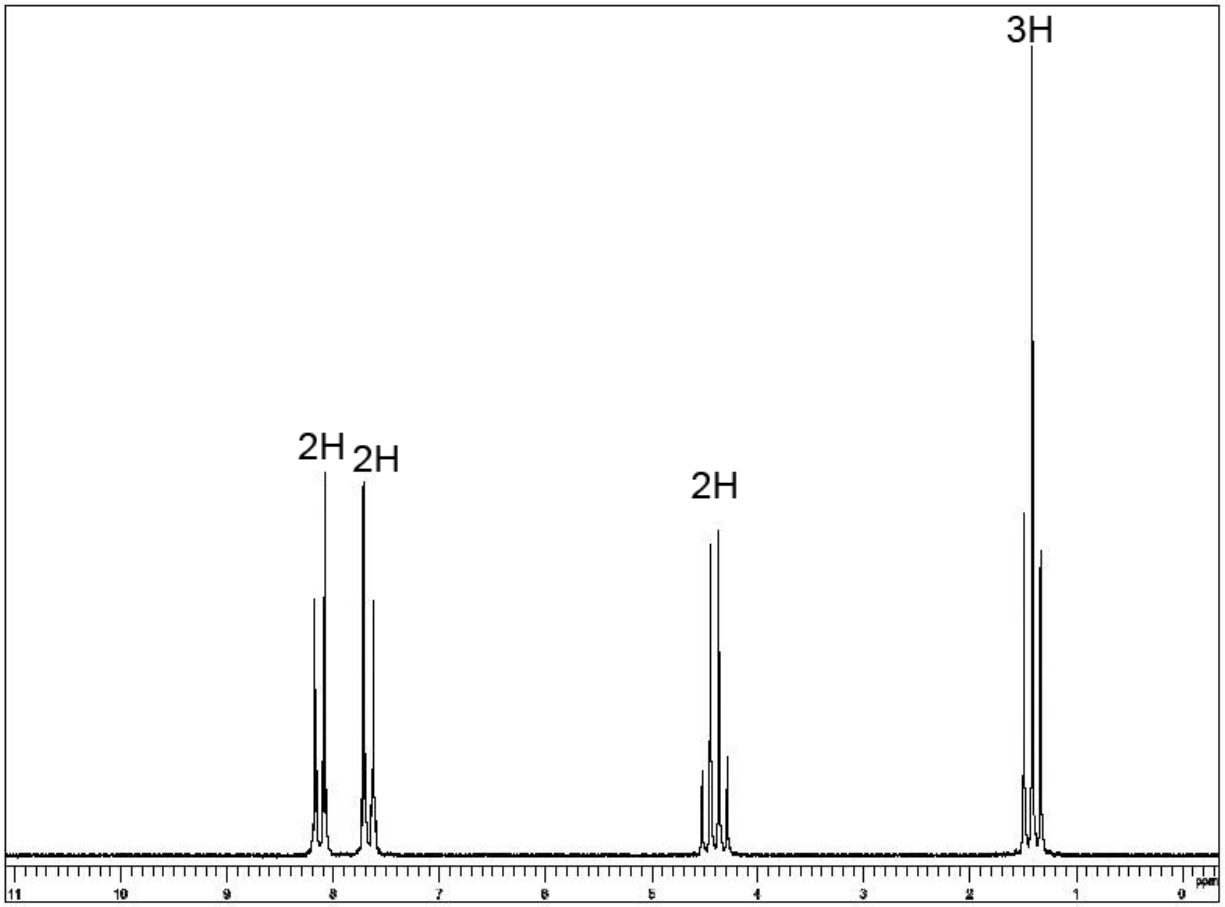
a) **ON THIS PAGE**: record any analysis using unsaturation number, ^{13}C NMR, and/or IR for up to 4 points *extra* credit.

b) **ON THE PAGE WITH THE HEADING "EXTRA SPACE FOR PROBLEM // WORK":** Use the ^{1}H NMR data to construct a table (chemical shift, integration, multiplicity, assignment) to identify structural fragments, then arrive at the structure. **For each fragment, underline the hydrogens that give rise to that signal.**

You are being graded on your analysis. A correct structure with no analysis receives zero credit.




200
180
160
140
120
100
80
60
40
20
0
ppm


3H
2H
2H
2H
11
10
9
8
7
6
5
4
3
2
1
0
ppm

(extra page for Problem 14 work)

Extra credit (20 points)

Professor Taber will be retiring soon, so to mark the occasion this semester's extra credit draws from his work. The reactions on the following page are taken from his synthesis of the steroid (-)-androst-4-ene-3,16-dione (**1**).

14. (15 points) Supply appropriate reagents for the arrows labeled "a" through "e" (on the next page).

15. (5 points) the conversion of **8** to **9** (aqueous base followed by acidification), and of **10** to **1**, involve chemistry you are already familiar with. Each conversion involves more than one reaction that you are familiar with happening in tandem. The individual reactions involved are (in alphabetical order):

Acetal hydrolysis

Aldol

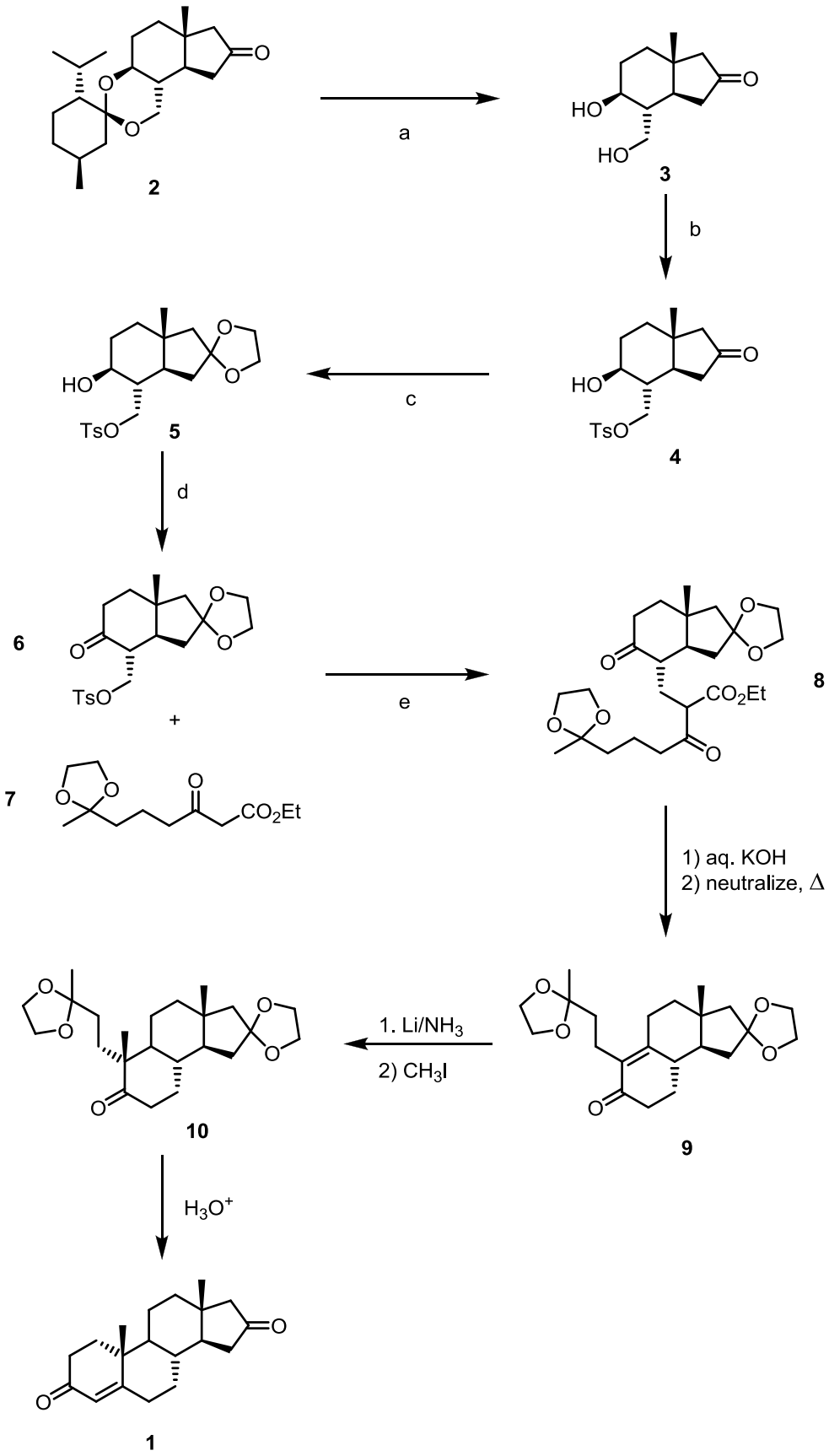
Decarboxylation

Saponification

The conversion of **8** to **9** uses three of these, and the conversion of **10** to **1** uses two of these (i.e. one is used twice). Determine which events occurred in each step. *Note: this question will be graded as 1 point per correct answer, minus one point for each incorrect answer*.

8 to **9:**

10 to **1:**


2
a
3
b
4
c
5
d
6
TsO
+
7
CO2Et
e
8
CO2Et
1) aq. KOH
2) neutralize, Δ
9
1. Li/NH3
2) CH3I
10
H3O+
1

Approximate ^{1}H NMR Chemical Shifts

Hydrogen	δ (ppm)
CH_3	0.8–1.0
CH_2	1.2–1.5
CH	1.4–1.7
$C{=}C{-}CH_x$	1.7–2.3
$O{=}C{-}CH_x$	2.0–2.7
$Ph{-}CH_x$	2.3–3.0
$\equiv C{-}H$	2.5
$R_2N{-}CH_x$	2.0–2.7
$I{-}CH_x$	3.2
$Br{-}CH_x$	3.4
$Cl{-}CH_x$	3.5
$F{-}CH_x$	4.4
$O{-}CH_x$	3.2–3.8
C=CH	4.5–7.5
Ar–H	6.8–8.5
O=CH	9.0–10.0
ROH	1.0–5.5
ArOH	4.0–12.0
RNH_x	0.5–5.0
$CONH_x$	5.0–10.0
RCOOH	10–13

Approximate ^{13}C NMR Chemical Shifts

Carbon	δ (ppm)
Alkanes	
Methyl	0–30
Methylene	15–55
Methine	25–55
Quaternary	30–40
Alkenes	
C=C	80–145
Alkynes	
C≡C	70–90
Aromatics	110–170
Benzene	128.7
Alcohols, Ethers	
C–O	50–90
Amines	
C–N	40–60
Halogens	
C–F	70–80
C–Cl	25–50
C–Br	10–40
C–I	–20–10
Carbonyls, C=O	
$R_2C{=}O$	190–220
RXC=O (X = O or N)	150–180

Approximate IR Absorption Frequencies

Bond	Frequency (cm^{-1})	Intensity
O–H (alcohol)	3650–3200	Strong, broad
O–H (carboxylic acid)	3300–2500	Strong, very broad
N–H	3500–3300	Medium, broad
C–H	3300–2700	Medium
C≡N	2260–2220	Medium
C≡C	2260–2100	Medium to weak
C=O	1780–1650	Strong
C–O	1250–1050	Strong