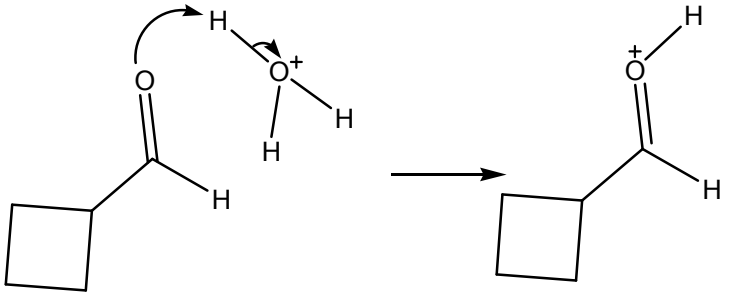
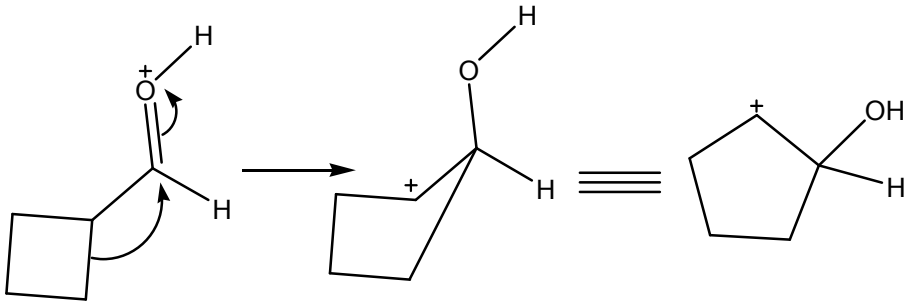
CHEM 303
Organic Chemistry II
Exam II
April 19, 2007
Answers

1) When cyclobutanecarbaldehyde is heated with acid, it is converted to a substance of formula C_5H_8O that reacts readily with 2,4-dinitrophenylhydrazine, but not with cold, aqueous permanganate, nor with cold CrO_3. Propose a structure for this product, and a mechanism for its production.

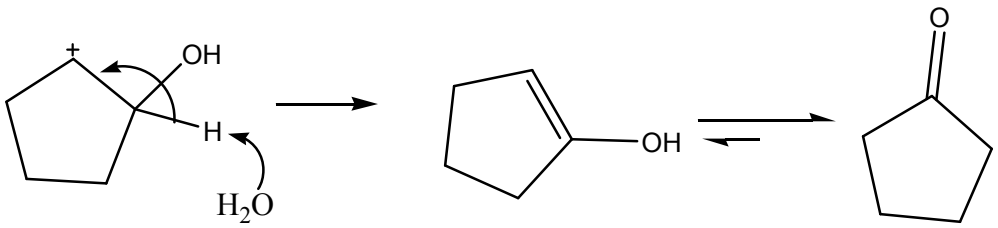
The reaction data tells us two important things: (a) that we still have a carbonyl [the 2,4-DNP reaction], and (b) that we do not have an aldehyde [no reaction with either $KMnO_4$ or cold CrO_3]. Therefore, we must have a *ketone*. The question is: what ketone, and how to get there. The formula shows that we have not had an addition reaction of any kind (we start with C_5H_8O and we end with C_5H_8O) so we have had a rearrangement. Let's start a process:



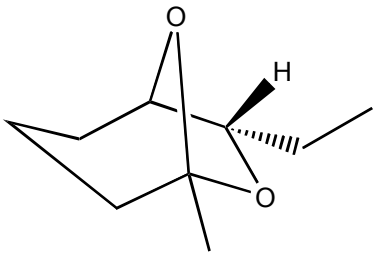
The protonated aldehyde on the right can be opened by a carbon-carbon bond migration (which also would relieve some ring strain):



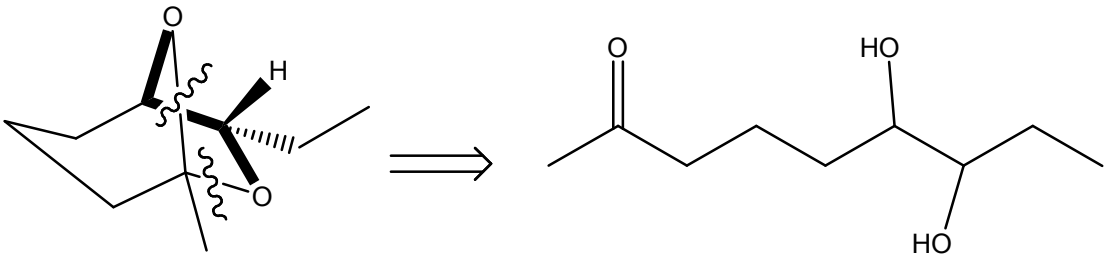
Finally, elimination to yield the enol, which tautomerizes to the ketone, cyclopentanone completes our scheme and gives us our final product:



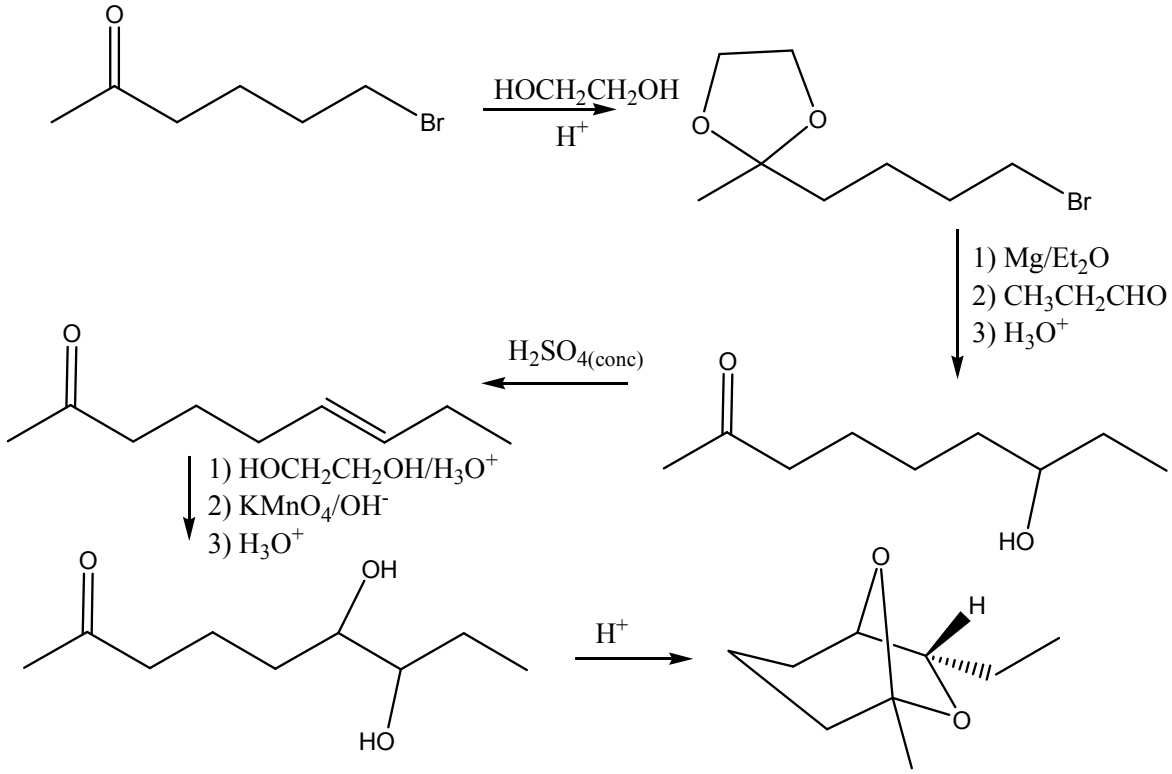
2) The ketal shown below (exobrevicomin) has been identified as a pheromone of the Western pine beetle. Give the structure of a dihydroxyketone that on treatment with anhydrous acid with undergo intramolecular conversion to the ketal shown. Propose a synthesis of the ketal starting with 6-bromo-2-hexanone and any other organic of 3 carbons or less. *Hint*: First find the carbon that is the carbonyl carbon atom of the dihydroxyketone.



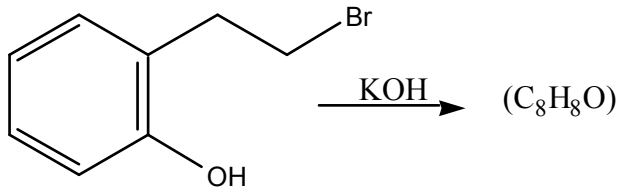
Well, since we know that ethylene glycol forms good ketals with ketones and aldehydes, we should (probably) look for the ethylene glycol-like part of this ketal, and then break those bonds to give the dihydroxyketone we need.



Now to the synthesis. We are only allowed three carbons or less plus 6-bromo-2-hexanone. There are a couple of ways to go about this. One way I saw used a Wittig reagent. I allowed this, but technically the Wittig is an organic reagent, and we don't know how to make triphenylphosphine. Here is another way I saw it:

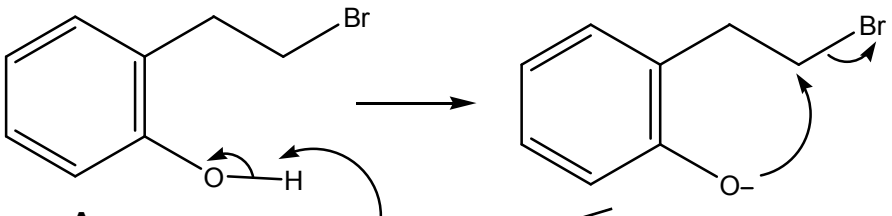


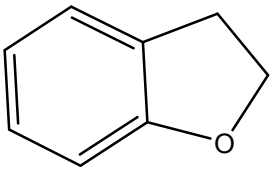
3) On treatment with KOH, compound A (shown below) is converted to B (C_8H_8O), which does not have an absorbtion in the 3200-3600 cm^{-1} region of its IR spectrum. The ^{1}H-NMR spectrum of B shows the following resonancs: δ 2.7 (triplet, 2H), 3.8 (triplet, 2H), 7.2 (multiplet, 4H). Suggest a structure for B and propose a mechanism to account for its formation.



A **B**

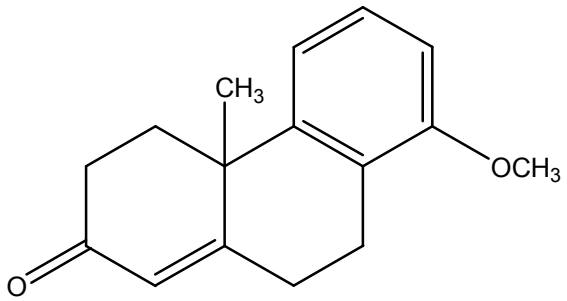
The lack of absorptions in the –OH region means that that the –OH group is not there. The formula of **B** shows that one additional degree of unsaturation has been made, and the NMR data show two sets of deshielded hydrogens. It seems to me that **B** is 2,3-benzo-4,5-dihydrofuran (shown below) which is formed by the following mechanism:



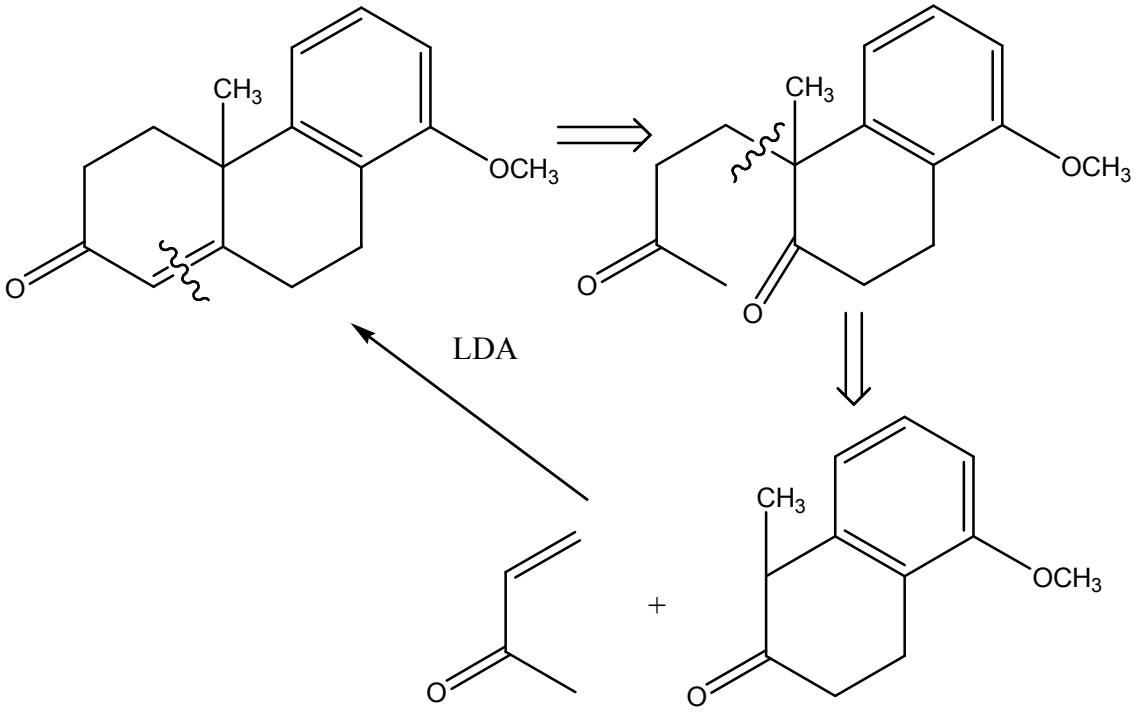


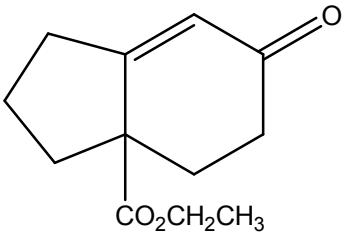
B

4) Propose syntheses of the following compounds using Michael addition followed by aldol condensations (*i.e.* Robinson annulation). Each of the compounds shown has been instrumental in one or more total syntheses of steroidal hormones:

a) 

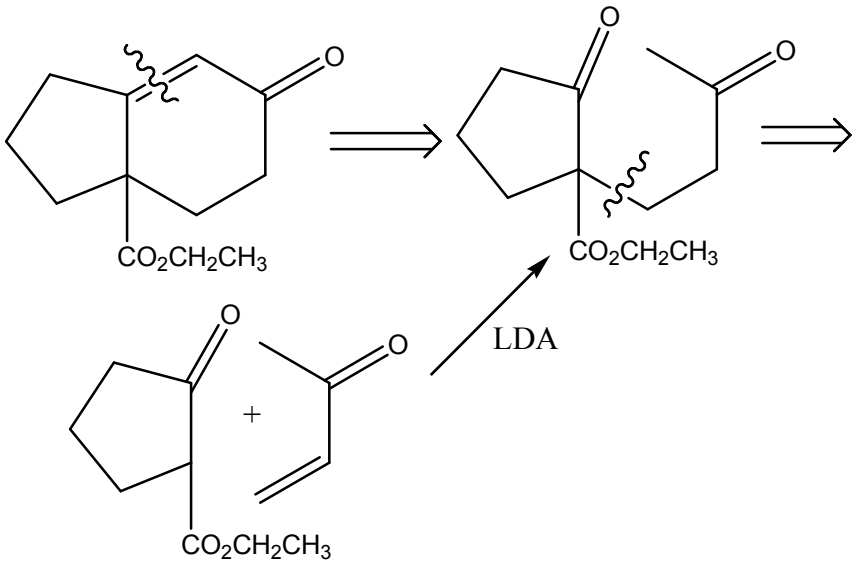
I'll approach this retrosynthetically, then at the end, fill in the reagents for the forward reaction. Taking the hint gives us the reverse of the Aldol first, then the reverse of the Michael addition:

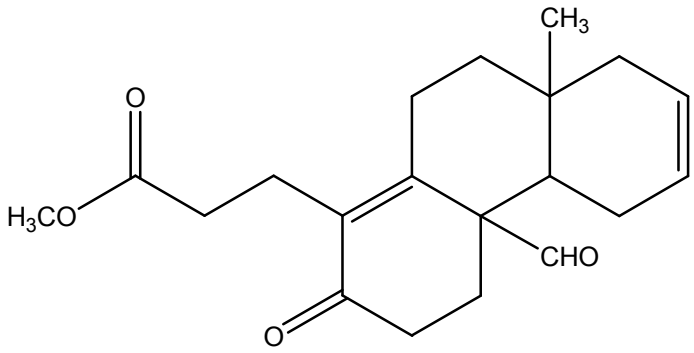




b)

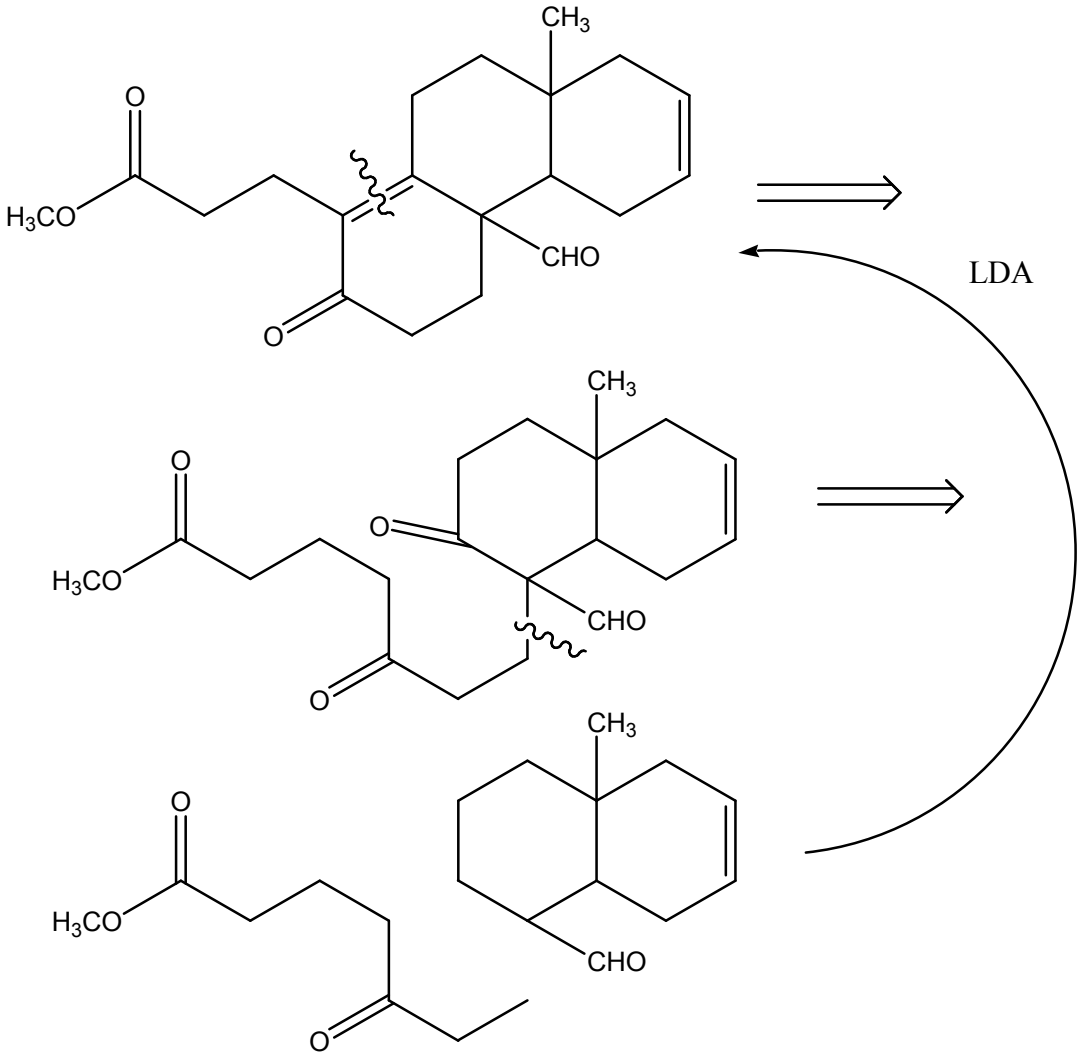
Same thing here. First the retrosynthetic analysis, then the reagents for the forward reaction:



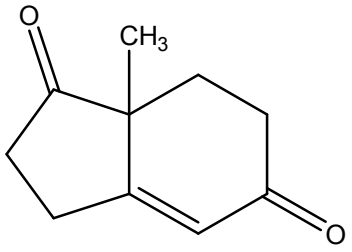


c)

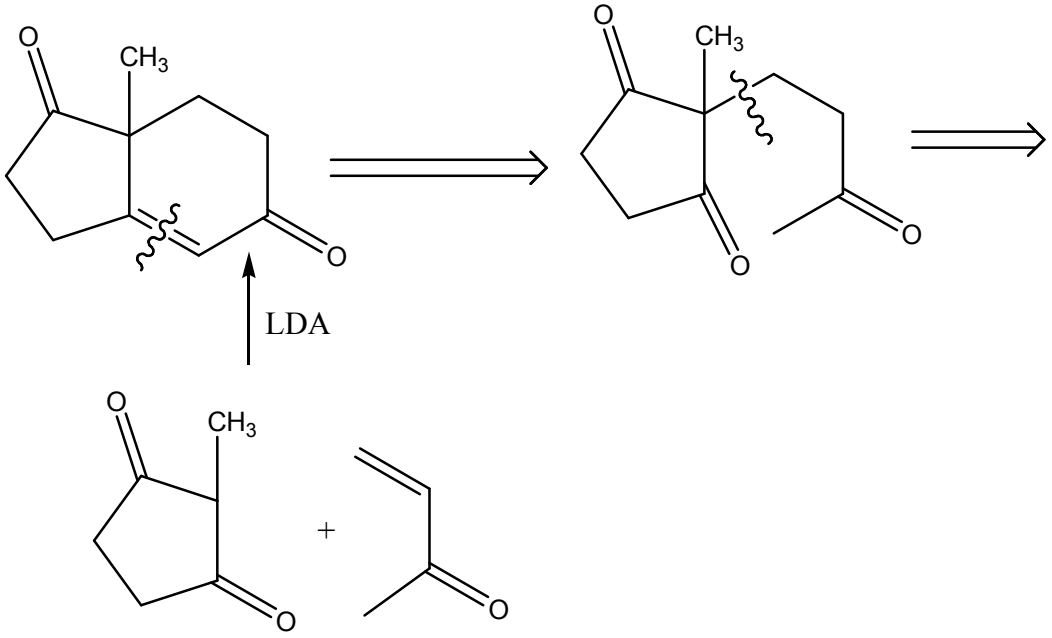
Again the same idea:



d)

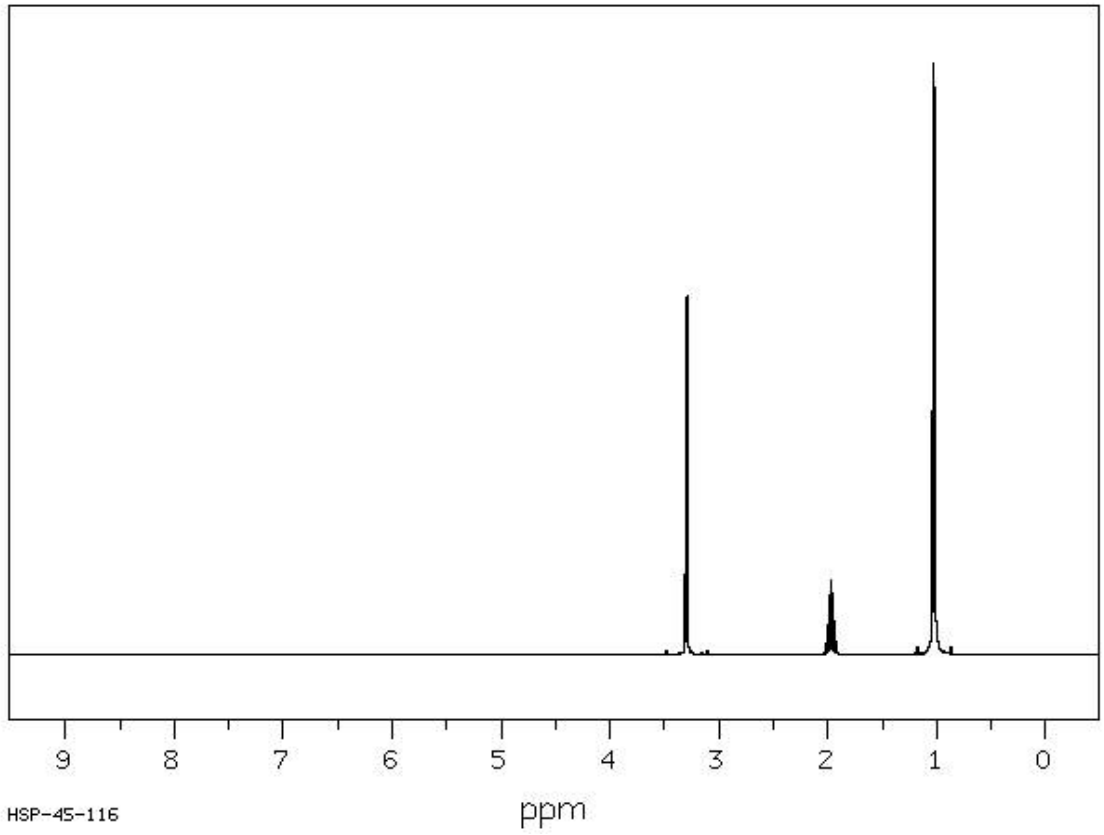


Are you tired of this same idea yet?



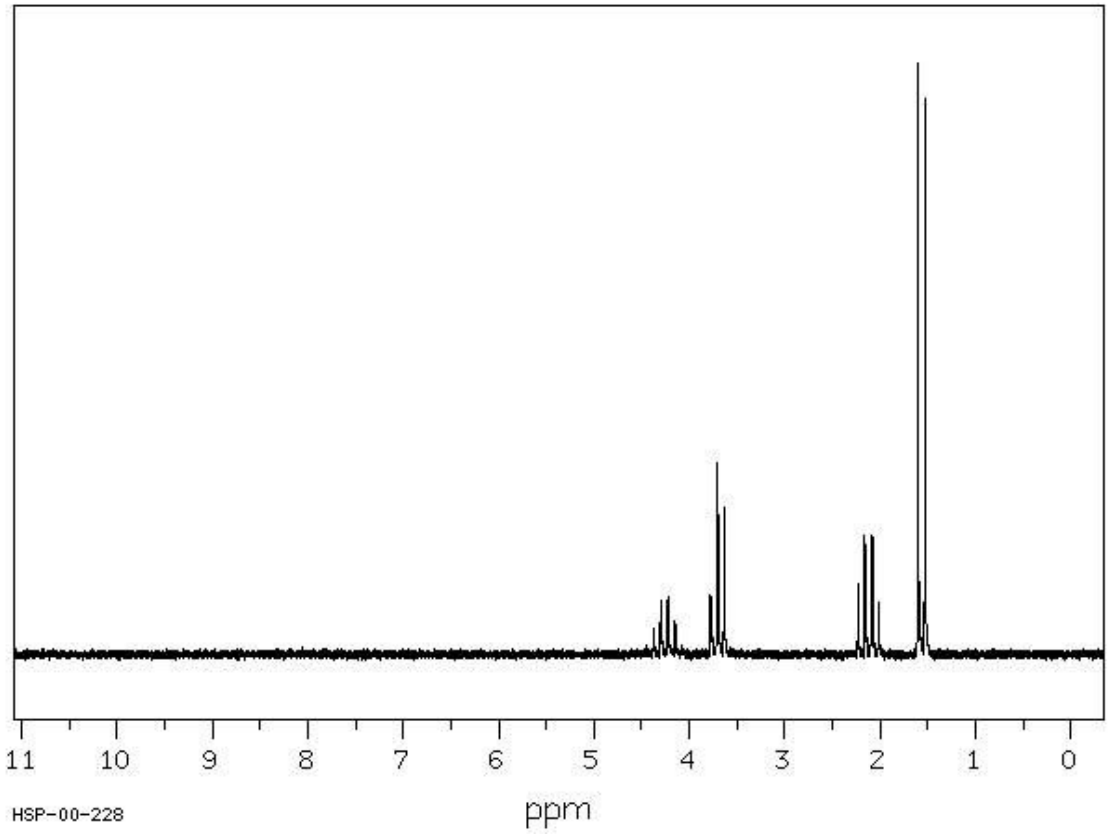
5) Propose structures for each of the following compounds given the ^{1}H-NMR spectra shown:

a) C_4H_9Br: (the most downfield and most upfield peaks are doublets with similar J values; the middle peak is a septet; integral is as shown)



A septet is a real dead give-away for an isopropyl group (or something quite similar). If an isopropyl group, there is C_3H_7 of our C_4H_9Br; that leaves CH_2Br. The integral fits this sort of ratio also. The formula shows no degrees of unsaturation, so it looks as if we have ***iso*-butyl bromide, $(CH_3)_2CHCH_2Br$**. (Yes, the methine should have more coupling; I don't know why it doesn't!)

b) $C_4H_8Cl_2$ (the most downfield peak is a pentet; the peak near 2.0 is a quartet, and the most upfield peak is a doublet, all with similar J values. Integral is as shown)



Here it's a bit harder. The quartet shows a group next to a methyl and the doublet, a group next to a methine. That accounts for C_2H_4. We have no degrees of unsaturation, so we are looking at an alkyl dichloride. The integral shows a 1:2:2:3 ratio, so we have a methine, two methylenes and a methyl (downfiedl→upfield). The downfield proton is clearly deshielded, and is therefore next to a chlorine atom. There is also a deshielded methylene, and a lesser deshielded methylene. It looks like this spectrum, given the formula, fits **1,3-dichlorobutane, $CH_3CHClCH_2CH_2Cl$**