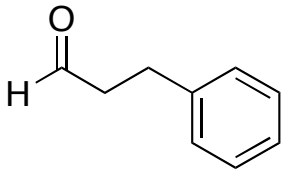
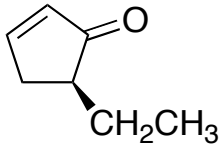
1. Provide an unambiguous name (IUPAC or common) for each of the following molecules. Be sure to indicate stereochemistry where appropriate. (10 points)



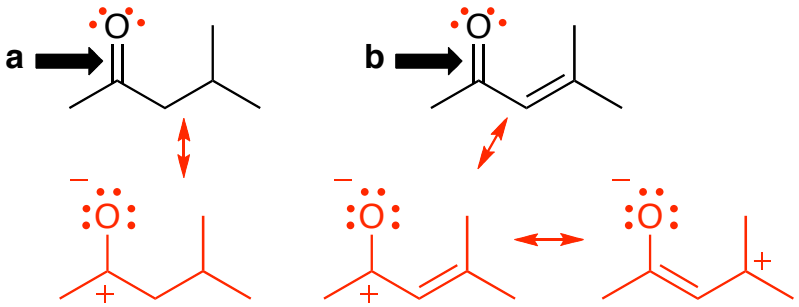
3-phenylpropanal



(*S*)-5-ethylcyclopent-2-enone

2. For each problem below, assign **a** and **b** to the spectroscopic data shown at the right. Then, using pictures *and* words, provide a rationale for your assignments. *Note: your **explanations** are worth more points than your answer choices*. (12 points)

A



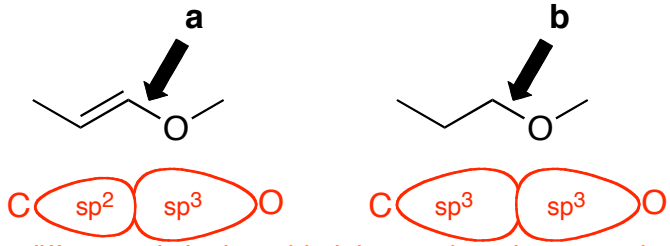
IR vibrational frequencies

b 1690 cm^{-1}

a 1717 cm^{-1}

Compound **b** has one extra resonance structure that contributes to the single bond character of the carbonyl bond. C-O single bonds are longer than C=O double bonds and therefore (all else being equal) will vibrate at lower frequencies.

B



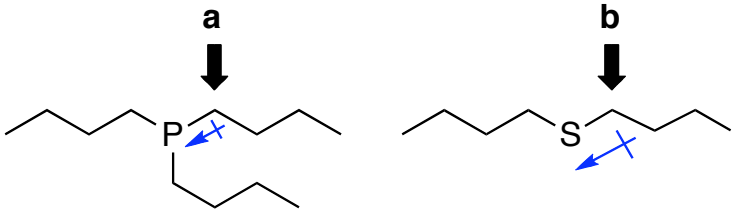
IR vibrational frequencies

b 1055 cm^{-1}

a 1250 cm^{-1}

The difference is in the orbital that each carbon atom is using to bond to oxygen. In **a**, an sp^2 orbital is used. In **b**, an sp^3 orbital is used. sp^2 orbitals have more *s* character and therefore are smaller (i.e. its electrons reside closer to the nucleus). Therefore, the bonds that an sp^2 hybridized atom forms will be shorter than those an sp^3 hybridized atom will form. The shorter the bond, the faster its stretching vibration and the higher its frequency of transition.

C



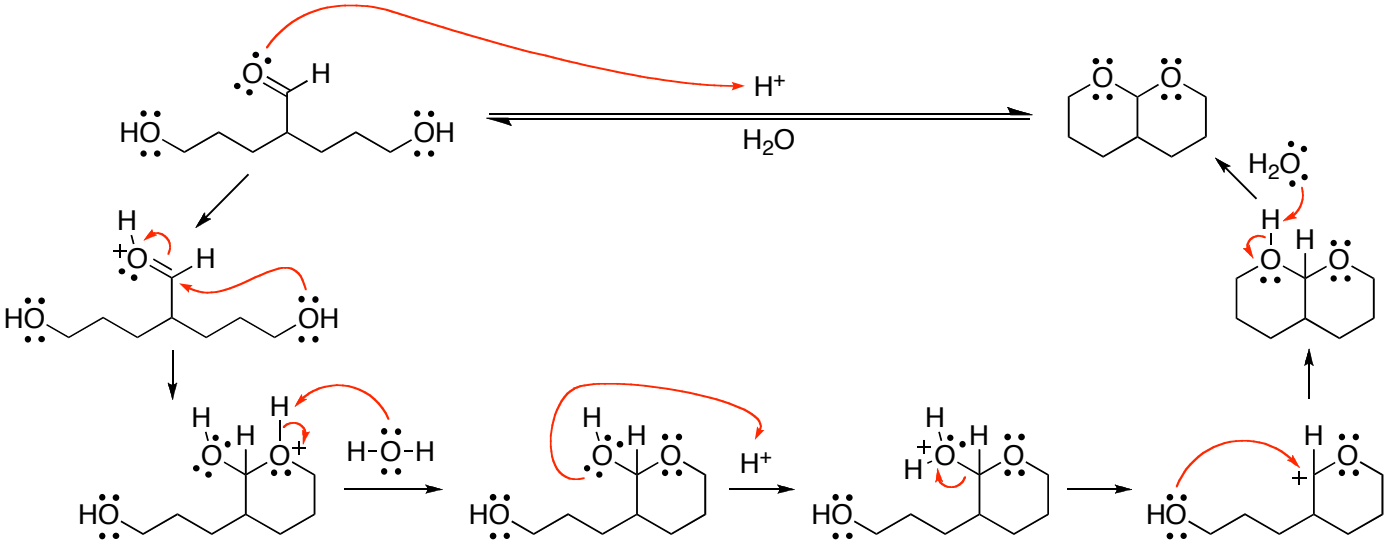
^{13}C NMR chemical shift

a 28.4 ppm

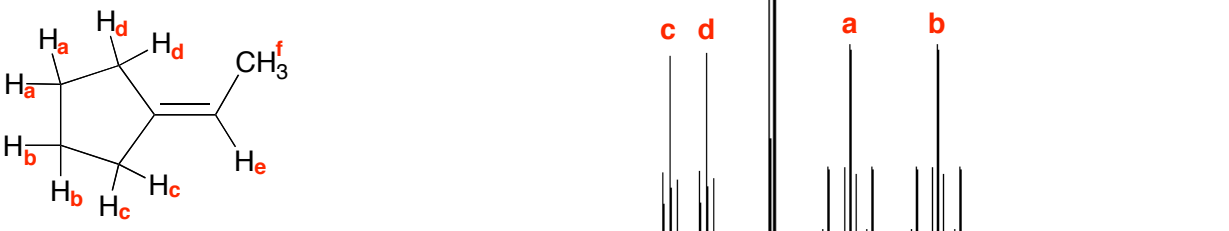
b 32.0 ppm

Sulfur is more electronegative than phosphorous. Sulfur will therefore have a greater affinity for the electrons in its bond to carbon. This greater affinity results in a greater deshielding effect on the carbon in the C-S bond than in the C-P bond. The more deshielded a carbon is, the more downfield it resonates in an NMR.

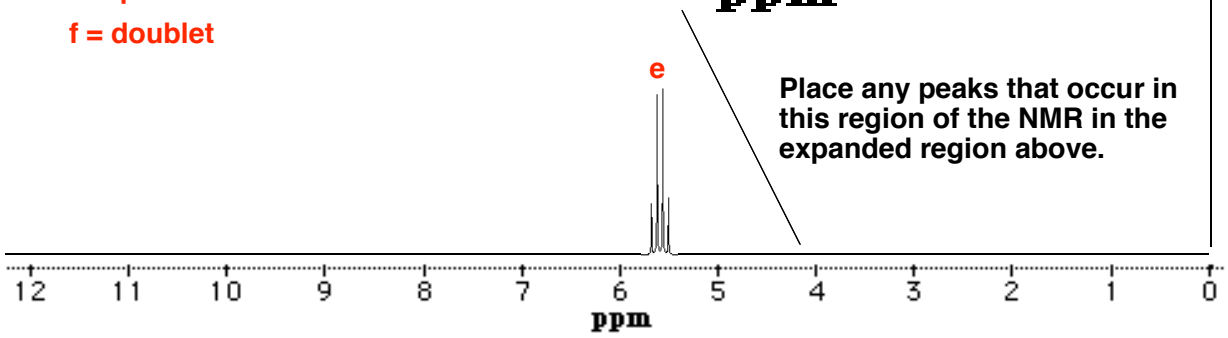
3. Provide a structure for the starting compound needed to produce the product shown. Then show the mechanism of its formation. Be sure to show all charges and lone pairs of electrons in your structures. If you cannot provide a structure, show as much of the reverse mechanism as you can. (12 points)



4. Predict the proton NMR spectrum of the following molecule. For full credit, you must assign your peaks *and* show all split peaks with the correct height ratios. (12 points)

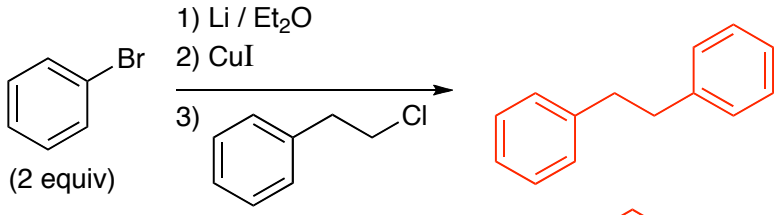


a & b = triplet of triplets
c & d = triplet
e = quartet
f = doublet

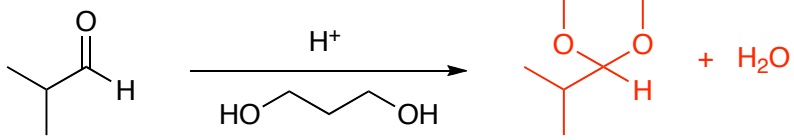


5. Complete the following reactions. If you provide more than one product, *circle the major product*(s). (30 points)

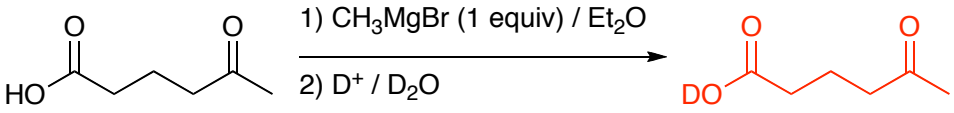
a)



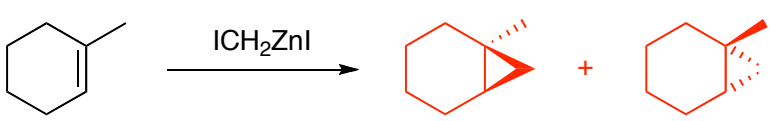
b)



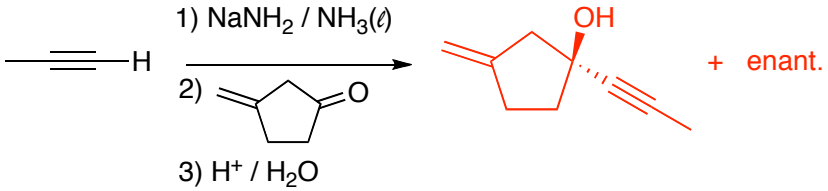
c)



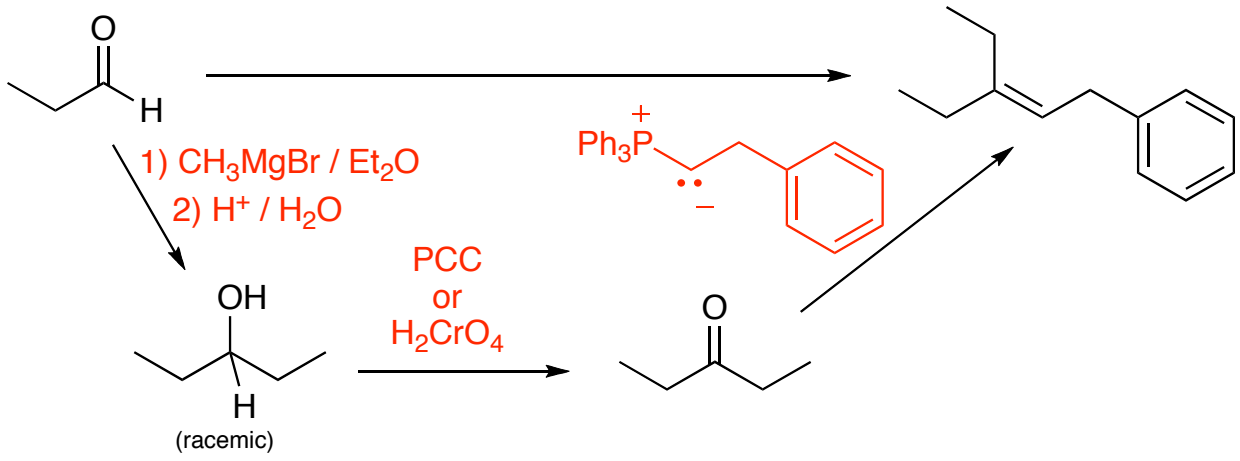
d)



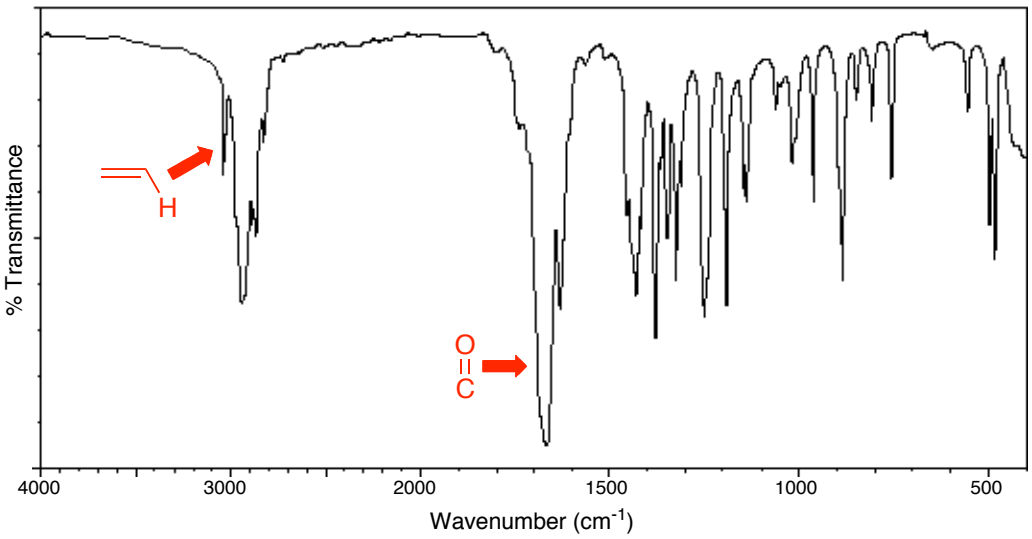
e)



6. Provide a synthesis for the following transformation. For full credit, be sure to draw all intermediary products along the way. (12 points)



7. A compound with the molecular formula $C_7H_{12}O_3$ gives the following spectra. Provide a structure and assign peaks in each spectrum for full credit. *Circle your answer*. (12 points)



D.U. = 3
one of them is C=C, another is C=O
the other could be a ring