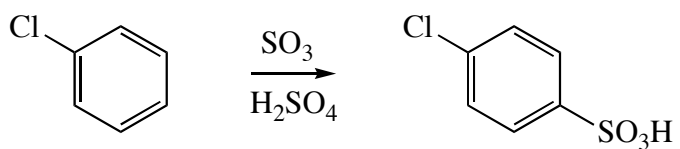
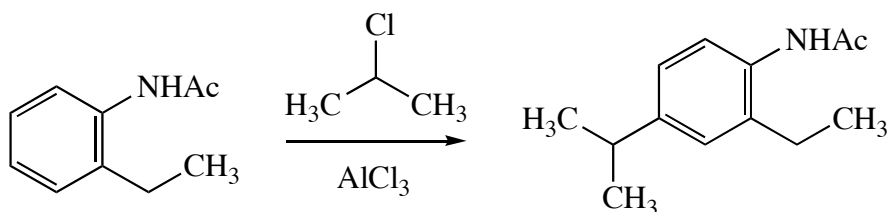


1. (4 pts. each, 24 pts. total.) Draw the *major* product of each of the following reactions, including the stereochemistry, if appropriate. **Do not draw mechanisms!**

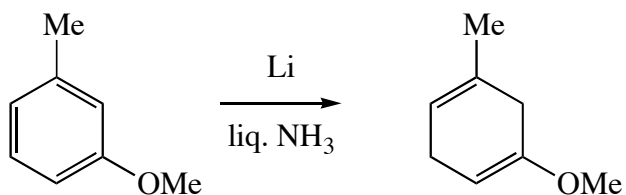
(a)



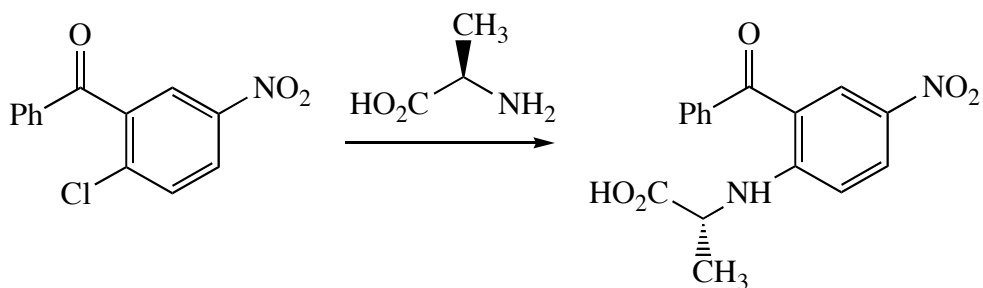
(b)



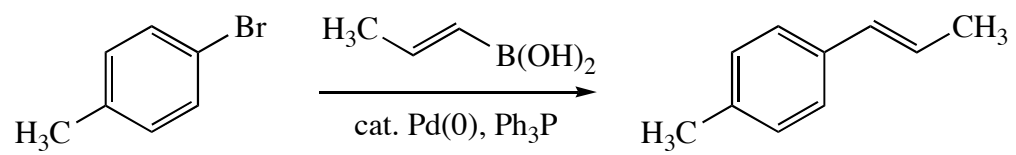
(c)



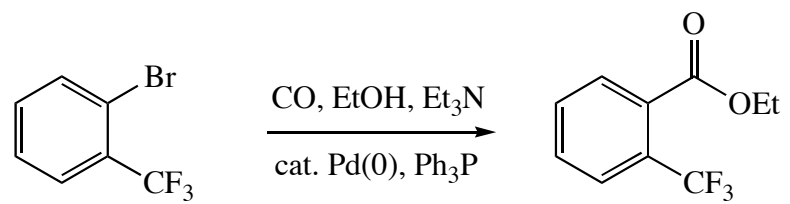
(d)



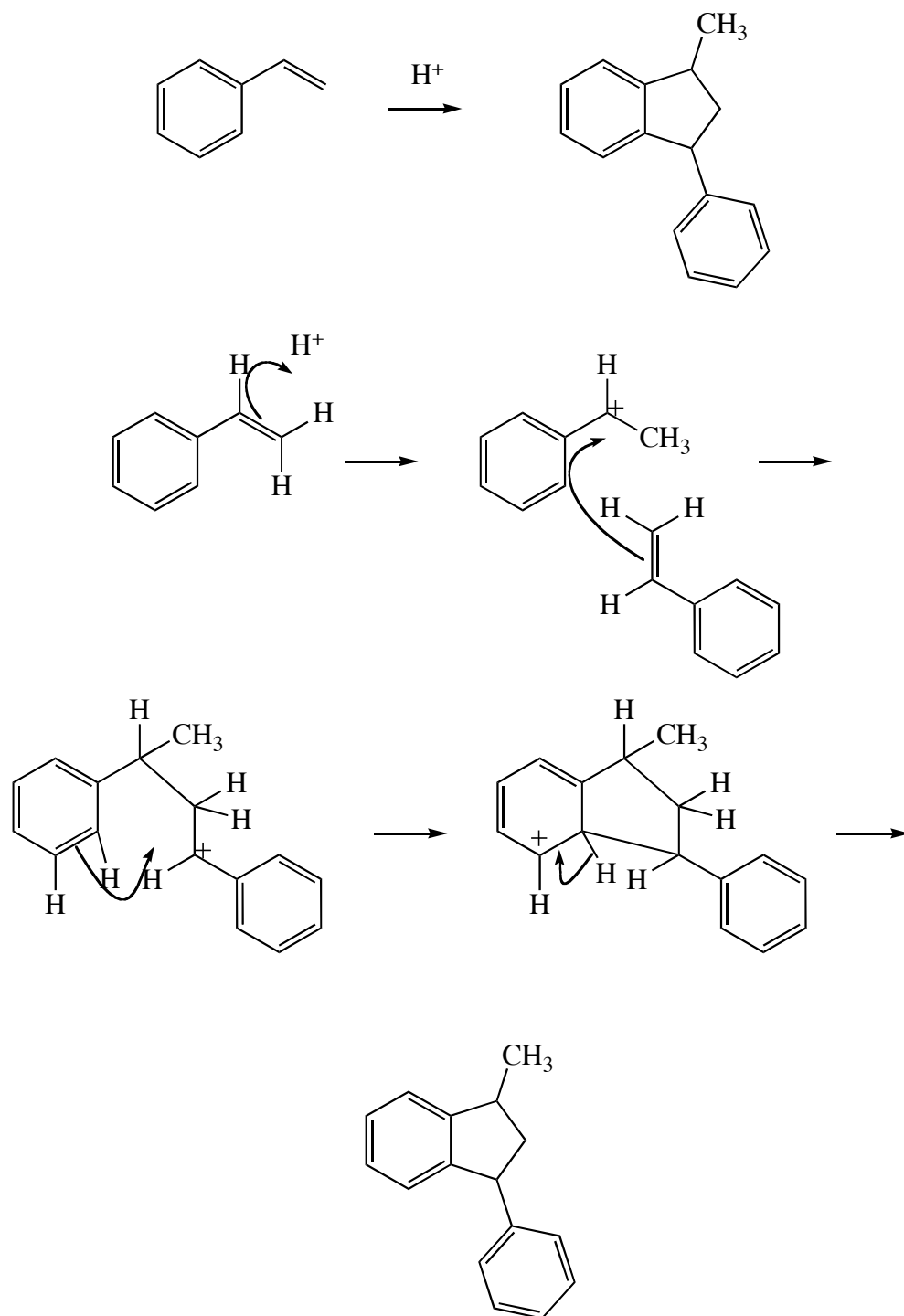
(e)



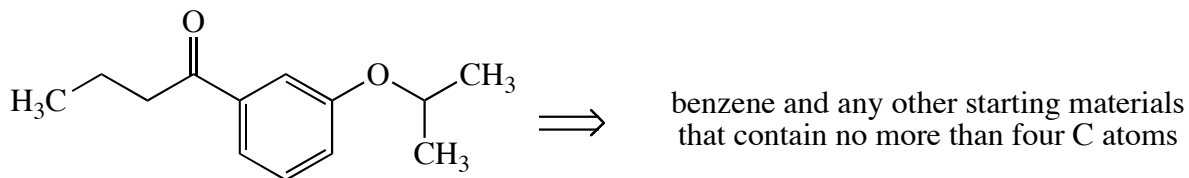
(f)



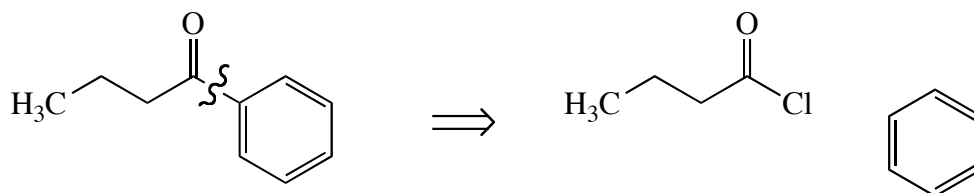
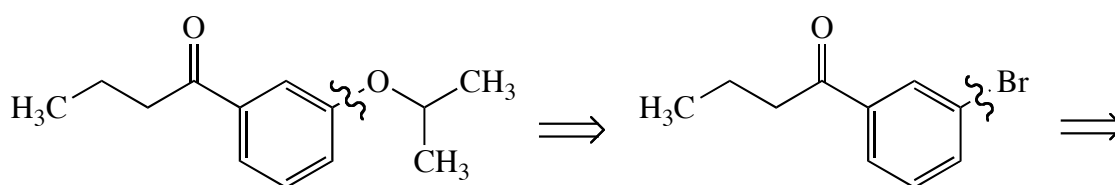
2. (16 pts.) Draw a reasonable mechanism for the following reaction. Use the conventional curved arrows to show the movement of electrons in each step. **You are strongly advised to obey Grossman's rule and to number your atoms.**



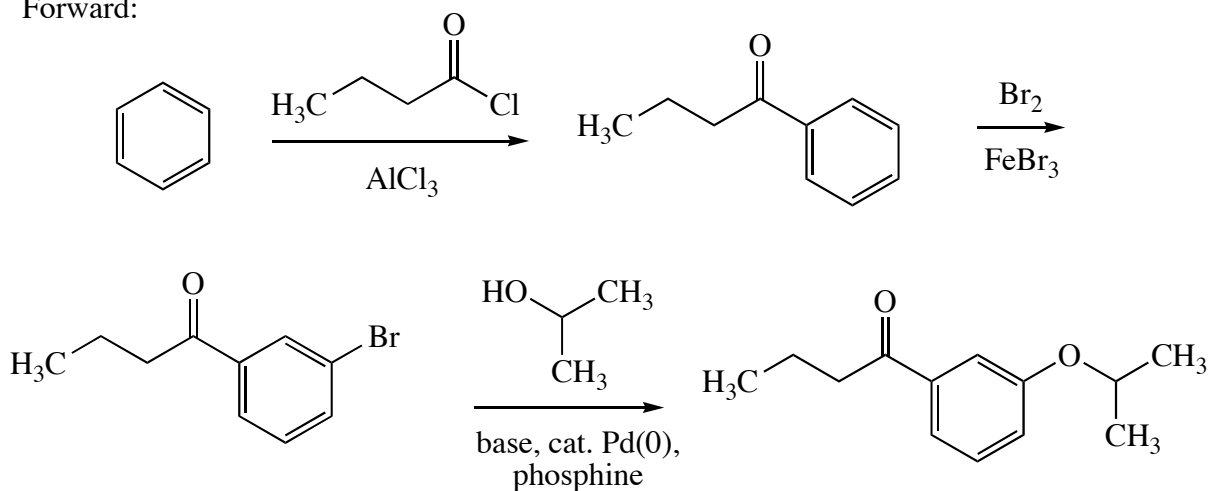
3. (16 pts.) Design a synthesis of the following compound from the given starting materials. The synthesis will require more than one step. Show each intermediate compound and all reagents you will need for each step. (Don't panic if you can't remember the reagents for a particular step; partial credit will be given.) There may be more than one correct answer. **Do not show mechanisms. You are strongly advised to do a retrosynthetic analysis before drawing the synthetic sequence in the forward direction.**



Retro:



Forward:



This answer is the shortest, but there are many other correct answers to this question.

4. (20 pts. total.) The last two pages of this exam show the MS and IR spectra of an organic compound. Answer the following questions using these spectra.

(a) (4 pts.) How many N, Cl, and Br atoms are present in this compound?

N: 0 or even

Cl: 1 (M and M+2 in 3:1 ratio)

Br: 0

(b) (8 pts.) Based on the MS spectrum *only*, propose *two* reasonable formulae for this compound, and indicate the number of degrees of unsaturation for each.

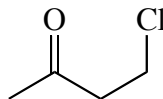
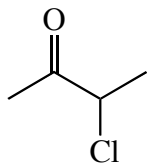
$106 - 35 = 71$. Max. C atoms = 5. $C_5H_{11}Cl$ has 0 DU, which is reasonable.

Formula 1: $C_5H_{11}Cl$ Degrees of unsaturation: 0

Formula 2: C_4H_7ClO Degrees of unsaturation: 1

(c) (8 pts.) Draw *two* structures consistent with your answer to (b) *and the IR spectrum*.

IR shows carbonyl absorbance at 1724 cm^{-1} . Indicates ketone. Can't be an aldehyde because there is no absorbance at 2750 cm^{-1} .



5. (4 pts. each, 24 pts. total.) Clearly explain why each of the following observations is **WRONG**. Use one or two grammatically correct English sentences and as many structural drawings as you need. Simply rewording the assertion in the negative will not earn you any points; I want a physical or chemical explanation of why the assertion is incorrect.

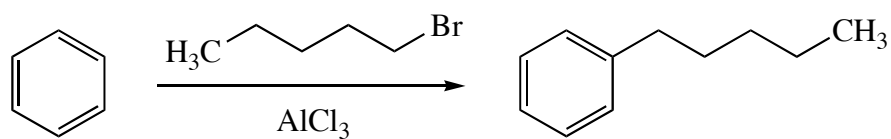
(a) An alkene will always show an IR absorbance around 1600 cm^{-1} .

The intensity of an IR absorbance depends on the change in dipole moment. If an alkene is symmetrical, it won't show an absorbance at all.

(b) If the heaviest peak in the MS of a compound weighs 101 amu, it must contain a N atom.

If a compound's molecular ion has an odd weight, it must have an odd number of N atoms. However, if a compound fragments every time it passes through the mass spectrometer, then the heaviest peak may represent a fragment, not the molecular ion. A compound with no N atoms will have fragments with odd masses.

(c) The Friedel–Crafts reaction of 1-bromopentane with benzene (catalyzed by AlCl_3) will give pentylbenzene.

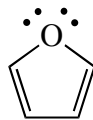


Primary carbocations are very high in energy. The nascent carbocation will undergo a 1,2-shift to give a secondary carbocation.

(d) Pd-catalyzed aromatic substitution reactions of aryl halides work because the Pd enables the nucleophile to do an $\text{S}_{\text{N}}2$ reaction on the aromatic ring.

No, they work because the Pd atom undergoes an oxidative addition to the C-X bond, and the nucleophile can then do an $\text{S}_{\text{N}}2$ substitution on the Pd atom.

(e) Furan has eight electrons (two π bonds and two lone pairs) in a cyclic array of p orbitals, so it is antiaromatic.



One of the lone pairs of O is in a p orbital, but the other is in a hybrid orbital that is orthogonal to the plane of the p orbitals. As a result, furan has six electrons in its π system, and it is aromatic.

(f) F is the most electronegative element, so it acts as a meta director in electrophilic aromatic substitution reactions.

F has lone pairs that can stabilize carbocations, despite its electronegativity, so it directs electrophilic aromatic substitution to the ortho and para positions.