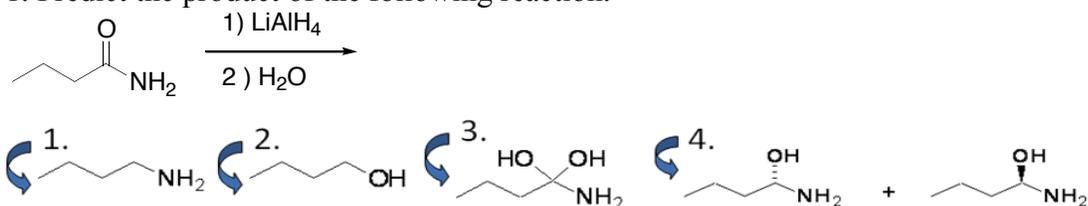
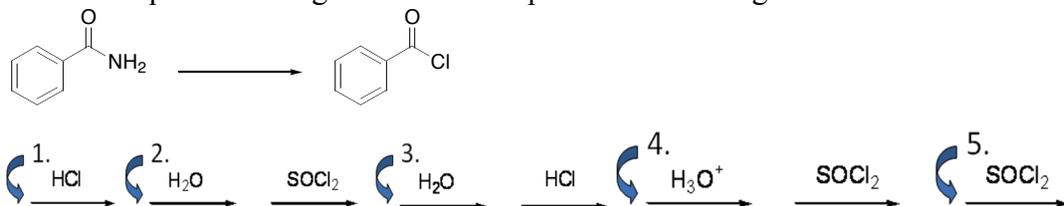


1. Predict the product of the following reaction.

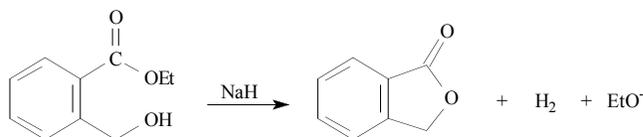


2. What sequence of reagents will accomplish the following transformation?



3. The ester ethyl *p*-nitrobenzoate is more reactive towards nucleophilic acyl substitution than ethyl *p*-methoxybenzoate. Explain this reactivity difference using **both words and structures**.

4. Consider the reaction below to answer the following questions:



(1) This reaction is an example of:

- an *intermolecular* nucleophilic acyl substitution reaction
- an *intramolecular* nucleophilic acyl substitution reaction
- an *intermolecular*  $S_N2$  reaction
- an *intramolecular*  $S_N2$  reaction

(2) The purpose of the base catalyst in this reaction is:

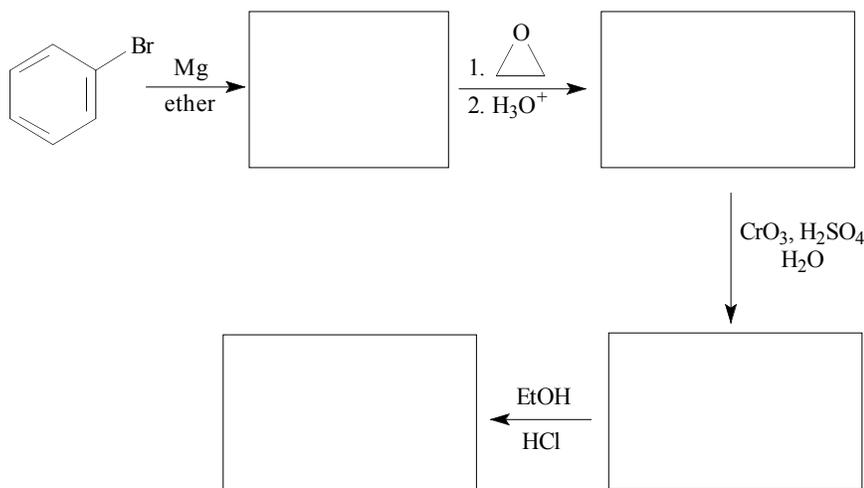
- to polarize the carbonyl group to make it more electrophilic
- to convert the ester to an intermediate carboxylic acid
- to convert the alcohol group to an alkoxide anion, which is a better nucleophile
- all of the above

(3) The product of this reaction is:

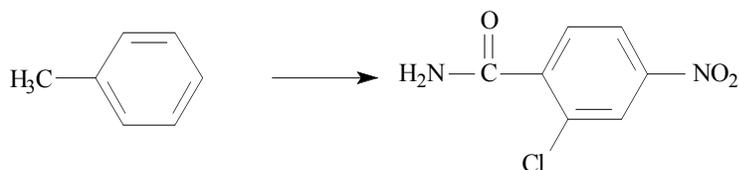
- a lactone
- an anhydride
- a lactam
- an ether

(4) Write the complete stepwise mechanism for this reaction. Show intermediate structures and all electron flow with arrows.

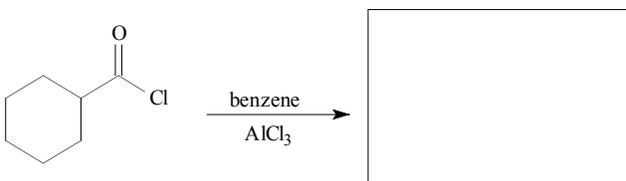
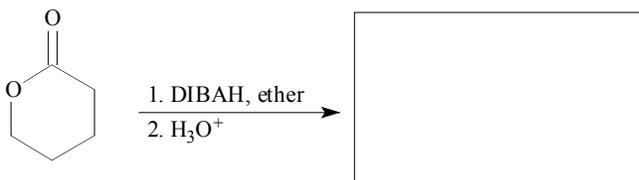
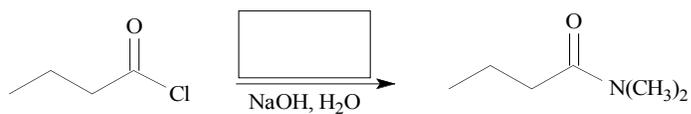
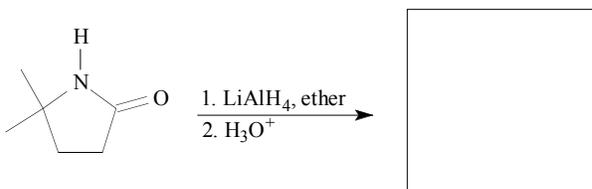
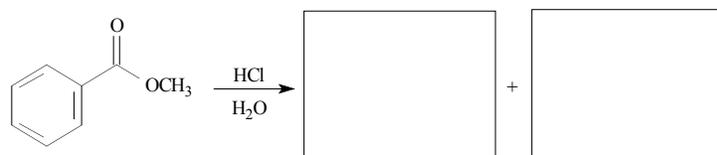
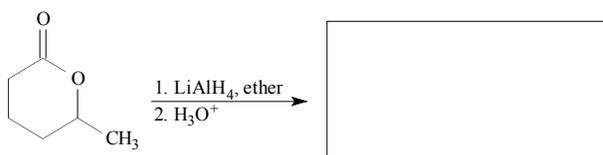
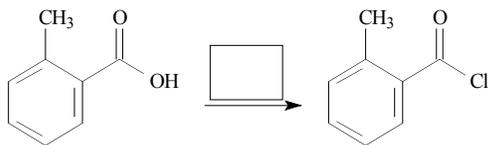
5. Ethyl phenylacetate is a pleasant smelling compound used in perfumery. Draw structures for each of the intermediates in the synthesis of ethyl phenylacetate below.



6. Aklomide, 2-chloro-4-nitrobenzamide, is an ingredient in veterinary antibacterial preparations. Propose a synthesis of aklomide starting with toluene. Show all reagents and all intermediate structures.



7. Provide structure(s) for the starting material(s), reagent(s) or the major organic product(s) of each of the following reactions or sequences of reactions. Show all relevant stereochemistry.



8. Propose a structure for  $C_4H_7ClO_2$ , that has the following IR and  $^1H$  NMR spectra.

Note:  $\delta$  1.8 is a doublet,  $\delta$  3.8 is a singlet and  $\delta$  4.4 is a quartet.

- (1) Calculate the degree of unsaturation for this compound.
- (2) What functional group is indicated by the IR data?
- (3) Propose a structure that is consistent with the provided spectroscopic data.
- (4) In your final structure label the non-equivalent hydrogens as a, b, c etc. and write those same letters above the corresponding peaks in the  $^1H$  NMR spectrum.

