1. a. Provide a mechanism for the following Claisen condensation:

\[ \text{CH}_3\text{COCH}_2\text{CH}_3 + \text{NaOEt} \rightarrow \text{CH}_3\text{COCOCH}_2\text{CH}_3 \]

b. Ethoxide ion is used as the base in the condensation above to avoid some unwanted reactions. Show what side reactions would occur if the following bases were used: NaOCH$_3$ or NaOH.

c. Esters with only one $\alpha$-hydrogen generally give poor yields in the Claisen Condensation. Why?

2. Predict products in the following reactions:

a. \[ \text{C-H} + \text{H}_3\text{C-COOEt} \rightarrow \text{NaOEt} \rightarrow \text{EtOH} \]

b. \[ \text{EtCOEt} + \text{NH}_2\text{C-CNH}_2 \rightarrow \text{NaOEt (cat)} \rightarrow \text{HOEt} \rightarrow \text{A} \] (Phenobarbital, a barbiturate)

4. Show the two organic starting materials that would be used to synthesize the following $\beta$-keto ester by a Crossed-Claisen Condensation. Give conditions for this synthesis.

\[ \text{H} + \text{B} \rightarrow \text{A} + \text{B} \]

5. Show the two organic starting materials that would be used to synthesize cinnamaldehyde by a crossed-aldol reaction. Give conditions for this synthesis.

\[ \text{Cinnamaldehyde} \rightarrow \text{A} + \text{B} \]
6. Unstabilized enolates do not work well in the Michael reaction, because 1,2 addition strongly competes (will get a mixture of 1,2 and 1,4 addition.)
   a. Show the two products that you would isolate if the enolate of acetone reacts with methyl vinyl ketone (MVK).

   ![Chemical Reaction](image)

   To make this reaction give only 1,4 addition, you can use an acetoacetic ester, which gives a stabilized enolate, or you can use the enamine of acetone. When an enamine is used as a nucleophile in a Michael reaction, the reaction is called a **Stork enamine reaction**. The Stork enamine reaction gives exclusive 1,4-addition.

   b. *Predict the product in the following Michael reaction:*

   ![Chemical Reaction](image)

   c. *Predict the product of the following Stork enamine reaction:*

   ![Chemical Reaction](image)

   d. *When the product of a Michael reaction is treated with NaOH, H₂O, and heat, a Robinson Annulation occurs. Draw the product of the following Robinson Annulation:*

   ![Chemical Reaction](image)