1. (10 pts) Explain why the following reaction fails to give the product shown and then provide a sequence of reactions that allows for the clean formation of the product.

\[
\begin{align*}
\text{O} & \quad \text{OCH}_3 \\
\text{CH}_2 & \quad \text{C} \\
\text{O} & \quad \text{OCH}_3
\end{align*}
\]

The Grignard reagent reacts faster with the ketone than with the ester so the ketone must be blocked (protected), for example as an acetal, in order to get the desired product.

The first step provides the acetal, the second reacts at the ester, the quench step gives the tertiary alcohol, and finally the hydrolysis step converts the acetal back into the ketone.
2. (16 pts) Give the products $A$ through $H$ from the following sequence. The molecular formula data and the spectral information might help as clues.

$$
\text{HBr} \rightarrow \text{C}_5\text{H}_{11}\text{Br} \rightarrow \text{Mg, ether} \rightarrow \text{C}_5\text{H}_{11}\text{MgBr}
$$

$$
\text{OH} \rightarrow \text{E} \quad ^{13}\text{C NMR} = 200 \text{ ppm}
$$

$$
\text{PhLi, THF} \rightarrow \text{F} \quad \text{C}_{12}\text{H}_{17}\text{LiO}
$$

$$
\text{PCC} \quad \text{CH}_2\text{Cl}_2 \rightarrow \text{D} \quad \text{IR} = 3200 \text{ cm}^{-1}
$$

$$
\text{H}_3\text{O}^+ \quad \text{quench} \rightarrow \text{C} \quad \text{C}_6\text{H}_{13}\text{BrMgO}
$$

$$
\text{PhLi, THF} \rightarrow \text{F} \quad \text{C}_{12}\text{H}_{17}\text{LiO}
$$

$$
\text{H}_3\text{O}^+ \quad \text{quench} \rightarrow \text{G} \quad \text{IR} = 3200 \text{ cm}^{-1}
$$

$$
\text{Na}_2\text{Cr}_2\text{O}_7 \quad \text{H}_2\text{SO}_4 \rightarrow \text{H} \quad \text{IR} = 1700 \text{ cm}^{-1}
$$
3. (20 pts) Give the **major organic products** from each of the following reaction sequences. When there is more than one step, a product from each is expected.

a. 

\[ \text{Cyclohexane COOEt} \xrightarrow{\text{1. 2 PhMgBr, THF}} \xrightarrow{\text{2. H}_2\text{O}^+ \text{ (quench)}} \text{1.} \]

b. 

\[ \text{Cyclohexanol} \xrightarrow{\text{1. NaNH}_2, \text{ether}} \xrightarrow{\text{2. CH}_3\text{CH}_2\text{CH}_2\text{Br}} \text{1.} \]

c. 

\[ \text{Propene} \xrightarrow{\text{1. H}_3\text{PO}_4, \text{H}_2\text{O}} \xrightarrow{\text{2. PCC, CH}_2\text{Cl}_2} \text{1.} \]

d. 

\[ \text{PhOH} \xrightarrow{\text{1. Na}_2\text{Cr}_2\text{O}_7, \text{H}_2\text{SO}_4} \xrightarrow{\text{2. excess CH}_3\text{OH, catalytic H}^+} \text{1.} \]

e. 

\[ \text{Naphthalene} \xrightarrow{\text{1. NaBH}_4, \text{CH}_3\text{OH}} \xrightarrow{\text{2. H}_3\text{PO}_4, \text{heat}} \text{1.} \]
4. (12 pts) Give the major product formed under the following conditions and then a mechanism for its formation that includes any important resonance structures for intermediates that are formed.

5. (8 pts) Provide a complete mechanism for the following acid-catalyzed ether formation.
6. (12 pts) Provide a synthesis for each of the following compounds using only 1-propanol as the source of carbon. Show the products from each step in your syntheses but show retrosynthesis only if it helps you in the planning of the synthesis.
7. (12 pts) **Provide mechanisms** for the two following transformations and then give a *brief* explanation for the different regiochemical outcomes.

The regiochemical outcome of the first reaction is dictated by steric factors where the large PhLi reagent attacks the less hindered carbon in the epoxide ring. Protonation then gives the tertiary alcohol product shown.

Since the second reaction involves acidic conditions the epoxide is protonated which causes a buildup of positive charge on the adjacent C atoms. Most of the electron-deficiency will reside at the tertiary carbon, as exemplified by the tertiary carbocation possibility shown; the nucleophilic alcohol then attacks at the more positive carbon to yield the product.
8. (10 pts) **Provide a complete mechanism**, which includes important resonance structures where appropriate, that explains the following transformation.