1. Limonene is one of the compounds that give lemons their tangy odor. Show the structures of the products expected when limonene reacts with an excess of each of the following reagents.

- **BH₃/THF**
- **H₂O₂, NaOH**
- **O₃**
- **(CH₃)₂S**
- **OsO₄**
- **H₂O₂**
- **KMnO₄, hot**
- **H₂O**
- **H₂, Pt/C**
- **HBr gas**
- **HBr, H₂O₂**
- **Br₂, H₂O**
- **1. Hg(OAc)₂**
- **2. NaBH₄**
2. Show how you would make the following compounds from a suitable cyclic alkene.

![Cyclic Alkene Structures]

3. Propose a mechanism for the following reaction.

![Mechanism Diagram]

4. An unknown compound decolorizes bromine in carbon tetrachloride, and it undergoes catalytic reduction to give decalin. When treated with warm, concentrated potassium permanganate, this compound gives cis-cyclohexane-1,2-dicarboxylic acid and oxalic acid. Propose a structure for the unknown compound.

![Reaction Mechanism Diagram]

5. The following functional group interchange is a useful synthesis of aldehydes.

\[
R-\text{C≡C-} \xrightarrow{\text{NaOEt, EtOH}} R-\text{C=CH} \xrightarrow{\text{H_2, Pt}} R-\text{CH}_2
\]

(a) What reagents are typically used to perform this transformation?

(b) This functional group interchange can also be accomplished using the following sequence.

\[
R-\text{C≡C-} \xrightarrow{\text{NaOEt, EtOH}} R-\text{C≡C-OEt} \xrightarrow{\text{H_2O}} R-\text{CH}_2
\]

Propose a mechanism for these steps. (This is a challenging problem but you should be able to reason out a mechanism)

(c) Briefly explain why a nucleophilic reagent such as ethoxide adds to an alkyne more easily than to an alkene.

6. Draw the mechanism for reduction of an alkyne to a trans-alkene using sodium metal in liquid ammonia.