1. How would you make the following alkene by using the Wittig reaction in two ways. Show the complete electron-pushing mechanism for the best way.

2. a) Acetic acid has a pKa equal to 5. What is the major species present at neutral pH = 7 in aqueous solution.

   b) The pKa of protonated amines (ammonium salts) is 10. Are amines in our bio molecules protonated in the body at neutral pH?

   Use the Henderson-Hasselbach relationship in Chapter 20 or some of you may know this intuitively.

   \[ \rho_{\text{H}} = pK_a + \log \left( \frac{[A^-]}{[HA]} \right) \quad \Rightarrow \quad 10^{(\rho_{\text{H}} - pK_a)} = \frac{[A^-]}{[HA]} \]

   a) \[ \frac{[A^-]}{[HA]} = \frac{[A\text{C}_2\text{O}^\text{O}]}{[A\text{C}_2\text{O}^\text{H}]} = 10 \quad \Rightarrow \quad \text{major species is } A\text{C}_2\text{O}^\text{O} \]

   b) \[ \frac{[A^-]}{[HA]} = \frac{[R-NH_2]}{[R-NH_3]^+} = 10^{(10)} = \frac{1}{1000} \quad \Rightarrow \quad \text{major species is } R-NH_3^+ \]
3. The following synthesis involves a Grignard reaction. Write the reagents over the arrows and the isolated intermediate compounds. This is the easiest way and most general way to make a carboxylic acid.

\[
\begin{align*}
\text{MgBr} & \quad \text{Et}_2\text{O} \\
\text{Et}_2\text{O} & \quad \text{H}_3\text{O}^+ \\
\text{MgBr} & \quad \text{CO} = \text{O} \\
\end{align*}
\]

4. Give two ways to synthesize a carboxylic acid by oxidation.

\[
\begin{align*}
\text{R} & \quad \text{OH} \quad 1) \text{KMnO}_4, \text{H}_2\text{O}, \Delta \quad \text{R} & \quad \text{OH} \\
\text{R} & \quad \text{OH} \quad 2) \text{H}_3\text{O}^+ \\
\text{R} & \quad \text{OH} \quad \text{K}_2\text{Cr}_2\text{O}_7, \text{aq. H}_2\text{SO}_4 \\
\text{Ph} & \quad \text{OH} \quad \text{K}_2\text{MnO}_4, \Delta \\
\text{Ph} & \quad \text{OH} \quad \text{CrO}_3, \text{H}_2\text{SO}_4, \Delta
\end{align*}
\]
5. Give the mechanism of the following reaction both forward and reverse. This type of reaction is called nucleophilic acyl substitution.

6. Write the mechanism of the following reaction. Remember that you have to get rid of the nitrogen as NH$_4^+$ and replace it with OH from H$_2$O. This reaction is called acidic hydrolysis of a nitrile.