1. Complete the following table, giving the constitutional formula and stick structure of the product(s).

<table>
<thead>
<tr>
<th>reaction</th>
<th>product(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>potassium is added to ethyl methyl ether</td>
<td></td>
</tr>
<tr>
<td>2-methyl-1-propanol is added to a warm solution of Cr$_2$O$_7^{2-}$/H$^+$</td>
<td></td>
</tr>
<tr>
<td>1-butanol is warmed with thionyl chloride (SOCl$_2$)</td>
<td></td>
</tr>
</tbody>
</table>

2. Lipoic acid (thioctic acid) plays an essential role in biochemical redox processes. Indicate the laboratory reagents and conditions required for the following conversions.

(a) ![Diagram](attachment:image1.png)

(b) ![Diagram](attachment:image2.png)

3. The biological process corresponding to the conversion of dihydrolipoic acid into lipoic acid may be written as

\[
\text{S-S} \quad \text{(CH}_2\text{)}_4\text{COOH} \quad + \quad \text{NAD}^+ \quad \text{↔} \quad \text{S-S} \quad \text{(CH}_2\text{)}_4\text{COOH} \quad + \quad \text{NADH} \quad + \quad \text{H}^+
\]

The structure of NAD$^+$ is drawn below. Draw the structure of NADH.

![Diagram](attachment:image3.png)
4. When 2-phenyl-2-pentanol, A, is treated with concentrated sulfuric acid, a mixture of alkenes (B, C, and D) is formed. Compounds B and C are diastereoisomers. Compounds B and D (and C and D) are constitutional isomers. Give the structures and names for B, C, and D.

5. (+)-Citronellal is a widely occurring natural product, present in citronella oil, lemon and lemon grass. It is used as a soap perfume and in insect repellents.

(a) Give the molecular formula for citronellal.
(b) List the functional groups present in citronellal.
(c) Give the constitutional formula of the major product(s) formed when citronellal is treated with each of the following reagents.
   (i) $\text{Cr}_2\text{O}_7^{2-} / \text{H}^+$
   (ii) excess CH$_3$OH / catalytic amount H$_2$SO$_4$
   (iii) NaBH$_4$ in CH$_3$OH followed by H$^+$/H$_2$O
   (iv) H$_2$/Pd in ethanol
   (v) 3 M H$_2$SO$_4$
   (vi) HCl in CCl$_4$ solvent

6. Predict the products for the following reactions.

   (a) acetone is heated in excess methanol with a catalytic amount of H$_2$SO$_4$
   (b) ethylammonium chloride is treated with dilute sodium hydroxide

7. Give the reagents and reaction conditions required to carry out the following conversions. Note that more than one step may be necessary.

(a) \[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}_3 & \xrightarrow{\text{H}_2\text{SO}_4} \text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}_3 \\
\end{align*}
\]

(b) \[
\begin{align*}
\text{CH}_3\text{CH}_2\text{OH} & \xrightarrow{\text{Pd in ethanol}} \text{CH}_3\text{CH}_2\text{OH} \\
\end{align*}
\]

(c) \[
\begin{align*}
\text{CH}_3\text{CH}_2\text{OH} & \xrightarrow{3 \text{ M H}_2\text{SO}_4} \text{(CH}_3\text{CH}_2)_4\text{N Br} \\
\end{align*}
\]