1) The pK\textsubscript{a} values of acetic acid and trifluoroacetic acid are 4.5 and 0.9 respectively. Based on this information, which anion, \( \text{CH}_3\text{COO}^- \) or \( \text{CF}_3\text{COO}^- \), is a better leaving group?

2) Draw the Newman projection formulas of the conformations leading to both cis and trans alkenes in the following reaction:

\[
\begin{align*}
\text{OTs} & \quad \text{CH}_3\text{CH}_2\text{O}^-\text{Na}^+ \\
\text{ethanol} & \quad \text{heat} \\
\quad & \quad \text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_3
\end{align*}
\]

Point out which proton will be removed by the base and identify all the unfavorable interactions in the Newman projection. Use this information as your guide to predict which isomer is likely to predominate in the reaction. (N.b.: you need two Newman projection diagrams; one for the cis, and another one for the trans.)

3) Explain why the tertiary bromide on the left fails to give the corresponding alcohol product on treatment with a mixture of water and ethanol, although the compound shown on the right, also a tertiary bromide, reacts quite readily.

4) An optically pure nitrile, shown below, was required for a research project (not mine!). The student responsible for obtaining 10 g of this material was able to find only three-quarters of this amount; the rest had to be synthesized. Both (R) and (S) enantiomers of 2-bromobutane were available, so the student decided to perform the reaction involving (R)-2-bromobutane and NaCN in DMF. The reaction proceeded as expected (that is, it went in a forward direction), and the proud student combined the original nitrile sample with 2.5 g of the newly synthesized material. Routine measure of \( \alpha \) of the combined nitrile sample revealed that it was no longer optically pure. What went wrong? What was the optical purity of the sample? (This last part is a some harder question.)
5) Each of the following reactions gives a substitution product. Identify the major product in each case and indicates whether the reaction is likely to proceed via a bimolecular ($S_N2$) or a unimolecular ($S_N1$) mechanism.

a) $\text{OSO}_2\text{CF}_3 + \text{NaI}$ in acetone

b) $\text{OMs}$ in CH$_3$OH

c) $\text{Br}$ in 80% H$_2$O ethanol

d) $\text{Br}$ in DMF