1. (10 pts) Give a detailed mechanism (using arrows to show bonds being formed and broken) to show how the product is formed in the following reaction. You only have to show initiation and propagation steps.
2. (15 pts) Provide the major organic product from each of the following reactions.

a. \[
\text{OH} \quad \xrightarrow{\text{H}_2\text{SO}_4, \Delta} \quad \text{product}
\]

b. \[
\text{product} \quad \xrightarrow{\text{HCl}} \quad \text{Cl}
\]

c. \[
\text{OH} \quad \xrightarrow{\text{HBr}} \quad \text{Br}
\]

d. \[
\text{product} \quad \xrightarrow{\text{Br}_2, \Delta} \quad \text{Br}
\]

e. \[
\text{Br} \quad \xrightarrow{\text{NaOCH}_3, \Delta} \quad \text{product}
\]
3. (18 pts) **Give each of the following compounds acceptable names.** You may use either the IUPAC system or the common names for substituents.

a. \( \text{Bicyclo}[4.3.0]\text{nonane} \)

b. \( \text{3-Fluoro-6-methyl-3-heptene} \)

c. \( \text{trans-3-Isopropyl-cyclohexanol} \)

d. \( \text{cis-1-tert-Butyl-2-vinyl-cyclopentane} \)

e. \( \text{2-Bromo-5-propyl-oct-4-ene} \)

f. \( \text{Bicyclo}[4.3.2]\text{undecane} \)
4. (15 pts) Give the expected major product from the following reaction, then give a detailed mechanism (using arrows to show bonds being formed and broken) to show how it is formed.

\[
\begin{align*}
\text{OH} & \quad \text{H}^+ & \quad \text{Br} \\
\text{(- H}_2\text{O)} & \quad \text{Br} \quad \text{(- H}_2\text{O)} \\
\text{H} & \quad \text{O}^+ & \quad \text{H}^- \\
\end{align*}
\]

Draw a reaction profile (on the axes given below) that describes energy changes during the reaction.

\begin{tikzpicture}
    % Drawing the profile
    % Label places on the profile that correspond to transition states or reactive intermediates, and indicate the rate-determining step. Is the slow step unimolecular or bimolecular?
\end{tikzpicture}

Label places on the profile that correspond to transition states or reactive intermediates, and indicate the rate-determining step. Is the slow step unimolecular or bimolecular?
5. (12 pts) In the following elimination reaction, *explain the formation* of the three alkene products *by showing the mechanism* operating in this reaction (use arrows to show bonds forming and breaking).
6. (9 pts) **Draw structures** for each of the following compounds.

   a) *Trans*-2-chloro-3-nonene

   ![Structure of Trans-2-chloro-3-nonene]

   b) 1-Allyl-3-fluorocyclohexane

   ![Structure of 1-Allyl-3-fluorocyclohexane]

   c) Bicyclo[4.2.0]octane

   ![Structure of Bicyclo[4.2.0]octane]

7. (6 pts) Within each of the following series of reactive intermediates, **rank the species** in terms of their expected relative stabilities (1 = most stabilized, 3 = least stabilized).

   ![Series of reactive intermediates]

   ![Series of reactive intermediates close-up]
8. (15 pts) Molecular models may help with this answering this question.

a) For **trans-1-\text{-}t\text{-}butyl-2-methylocyclohexane** draw two chair forms that are related by a “ring flip” and indicate which of the two chair forms will be the **more stable**. Explain your choice.

![Chair forms of trans isomer](image)

Both large groups may be equatorial in this isomer

b) For **cis-1-\text{-}t\text{-}butyl-2-methylocyclohexane** draw two chair forms that are related by a “ring flip” and indicate which of the two chair forms will be **more stable**. Explain your choice.

![Chair forms of cis isomer](image)

Prefer to have larger \text{-}t\text{-}Butyl group equatorial in this isomer

c) **Compare your pictures** for the **cis-** and **trans-** isomers in parts a) and b) above and decide which of the two isomers (cis or trans) should be thermodynamically **more stable**. Explain your choice.

**trans-1-\text{-}t\text{-}Butyl-2-methylocyclohexane** will be more stable than the **cis** isomer since both of the large groups may be equatorial thus avoiding any destabilizing 1,3-diaxial interactions that (inevitably) occur in the **cis** isomer where the (smaller) methyl group has to be in an axial position.