Your job is to convince me you know what you are doing. Use your time wisely. Explanations needn’t be long!
“Mechanism” means use curved arrows, show intermediates if they exist, indicate non-zero formal charges, etc.

1. Propose a mechanism for the transformation shown below. (5 points)

2. Provide the structure of the major product expected in the reaction below and the complete mechanism by which it is formed. (5 points)

3. Which stereoisomer of the compound below, the cis or the trans, is expected to exhibit a faster rate in E2 reactions? Explain your answer. (6 points)
4. Provide structures of the alkyl halides that would serve as the best starting materials for the synthesis of these alkenes in one step with minimal unwanted side products. (6 points)

a. 

b. 

5. When the alcohol below is treated with HBr, compound A is the major product. When the alcohol is treated with H$_2$SO$_4$, a different compound, B, is produced as the major product.

a. Provide structures of A and B.

b. Explain why use of hydrobromic acid and sulfuric acid leads to different products. (i.e., what difference in the acids is responsible for the difference in the products?) (8 points)

Hydrobromic acid (HBr) is a strong acid and electrophilic, so it can lead to substitution reaction.

Sulfuric acid (H$_2$SO$_4$) is also a strong acid but it is not electrophilic like HBr. Therefore, it does not lead to substitution reaction.
6. Fill in the blanks. Provide the missing reactant(s), product(s), or reagent(s). (3 points each)

- \[ \text{Br} \to \text{O} \to \text{CH}_2\text{O} \to \text{H}_2\text{O} \to \text{NaOH} \to \text{OH} \]
- \[ \text{H}_2\text{C} \to \text{Br} \to \text{NaOH} \to \text{H}_2\text{O} \to \text{NaOH} \to \text{OTs} \to \text{?} \]
- \[ \text{Br} \to \text{CH}_2\text{OH} \to \text{NaBH}_4 \to \text{?} \]
- \[ \text{H}_3\text{C} \to \text{N(CH}_3)_3 \to \text{NaOH} \to \text{?} \]
- \[ \text{H}_2\text{C} \to \text{SOCl}_2 \to \text{NaCN} \to \text{DMSO} \to \text{?} \]
- \[ \text{H}_2\text{C} \to \text{CH}_2\text{Cl}_2 \to \text{CrO}_2\text{Cl}_2 \to \text{?} \]
- \[ \text{H}_2\text{C} \to \text{NaOCH}_2\text{CH}_3 \to \text{CH}_2\text{OH} \to \text{?} \]
- \[ \text{H}_2\text{C} \to \text{NaOEt} \to \text{EtOH} \to \text{?} \]
7. For each transformation shown below, state if it is an oxidation or a reduction. (4 points)

\[
\begin{array}{cc}
\text{Oxidation (increase in oxygen)} & \text{Oxidation (decrease in hydrogen)} \\
\text{C-H} & \text{C-H}
\end{array}
\]

8. Provide structures of the alkyl halide and alkoxide ion needed to produce the ether below via Williamson Ether Synthesis. (6 points)

\[
\begin{align*}
\text{Cyclopentanol} & \rightarrow \text{Cyclopentylmethyl ether} \\
\text{CH}_3^- & \rightarrow \text{CH}_3 \\
\text{No elimination possible}
\end{align*}
\]

9. Which substrate below is expected to give the highest ratio of substitution-to-elimination products in reaction with sodium ethoxide in ethanol? (4 points)

\[
\begin{align*}
\text{Br} & \rightarrow \text{Br} \\
\text{No elimination possible (no } \beta \text{- hydrogens)}
\end{align*}
\]

10. Which reaction conditions will result in the highest ratio of elimination-to-substitution products with bromocyclohexane as the substrate? (4 points)

\[
\begin{align*}
\text{EtOH} & \rightarrow \text{EtOH} \\
\text{EtOH} & \rightarrow \text{EtOH} \\
\text{EtOH} & \rightarrow \text{EtOH}
\end{align*}
\]

\[
\text{Strong base of hindered}
\]

11. Will it work? Each of the proposed syntheses below may or may not contain a design flaw. In each case, explain if the proposed syntheses is expected to work as written. If there is a flaw in the synthetic design strategy, explain what the problem is. (8 points)

\[
\begin{align*}
\text{HC≡CNa} & \xrightarrow{\text{HC≡CNa}} \text{H}_2\text{C} & \xrightarrow{1. \text{NaNH}_2, \text{NH}_3(\text{l})} \text{H}_3\text{C} \equiv \text{CH} & \xrightarrow{2. \text{H}^+} \text{H}_3\text{C} \equiv \text{CH} \equiv \text{OH} \\
\text{H}_3\text{C} \rightarrow \text{Br} & \xrightarrow{\text{H}_3\text{C} \rightarrow \text{CH}} \text{H}_3\text{C} & \xrightarrow{3. \text{H}^+} \text{H}_3\text{C} \equiv \text{CH} \\
\end{align*}
\]

Yes, will work!

\[
\begin{align*}
\text{HC≡CNa} & \xrightarrow{\text{HC≡CNa}} \text{H}_2\text{C} & \xrightarrow{2. \text{H}^+} \text{H}_3\text{C} \equiv \text{CH} \\

\text{H}_3\text{C} \rightarrow \text{Br} & \xrightarrow{\text{H}_3\text{C} \rightarrow \text{CH}} \text{H}_3\text{C} & \xrightarrow{2. \text{H}^+} \text{H}_3\text{C} \equiv \text{CH} \\
\end{align*}
\]

Won’t work!

Very strong base

will give elimination

12. Provide the reactions needed to perform the following synthetic transformations. (8 points)

\[
\begin{align*}
\text{H}_3\text{C} \xrightarrow{\text{Cl}} \text{CH}_3 & \xrightarrow{\text{OH}^-} \text{H}_3\text{C} \xrightarrow{\text{Cl}} \text{OH} \\
\text{H}_3\text{C} \xrightarrow{\text{Cl}} \text{CH}_3 & \xrightarrow{\text{OH}^-} \text{H}_3\text{C} \xrightarrow{\text{Cl}} \text{OH} \\
\text{H}_3\text{C} \xrightarrow{\text{Cl}} \text{OH} & \xrightarrow{\text{KOH}} \text{H}_2\text{O} \\
\end{align*}
\]

Gabriel Synthesis