1. (12pts) For these reactions, predict whether the reaction will go through an $S_N1$ or $S_N2$ mechanism. Draw the structures of the major substitution product(s) in the box and list the product of the reaction as optically active or optically inactive.

A. Type of mechanism: $S_N2$

optically active or inactive: **inactive**

B. Type of mechanism: $S_N2$

optically active or inactive: **inactive**

C. Type of mechanism:

optically active or inactive: **active**
2. (12 pts) Do the following compounds have enantiomers and/or diastereomers? If so, draw an appropriate structure in the box. If not, put an “X” through the entire box.

A. 

B. 

C. 

3. (15 pts) Give the name of this compound, including R/S designations. Draw both chair conformations of this structure. Indicate which one is more stable or if they are of equal stability.

Name: \((153^R)_1\)-chloro-3-ethyl/cyclohexane

chair conformation #1

chair conformation #2

more stable
4. (16 pts) When 2-butanol is treated with HBr, 2-bromobutane is produced. The mechanism is shown below, and is an acid/base reaction followed by an SN1 mechanism. Answer the questions below based on this mechanism.

![Mechanism Diagram]

A. Fill in the appropriate arrows in the scheme above.

B. Draw an energy diagram for this three-step mechanism with appropriate relative energies. (Assume the reaction is exothermic overall, the carbocation is the least stable intermediate, and the protonated alcohol is less stable than 2-butanol.)

![Energy Diagram]

C. Based on the mechanism, would the rate go up, down, or remain the same if more Br⁻ were added to the reaction? Explain.

Remain the same. Br⁻ reacts after the rate determining step.

D. Based on the mechanism, if the reaction were to start with (S)-2-butanol, would the bromide product be (R), (S), or a racemic mixture? Explain.

Racemic mix. When the carbocation forms, it is planar and can be attacked from both sides by Br⁻.
5. (16pts) Give the relationship of each pair of molecules as same, enantiomers, diastereomers, constitutional isomers, or no relationship. Circle any meso compounds.

A. 

\[ \text{relationship: } \text{enantiomers} \]

B. 

\[ \text{relationship: } \text{enantiomers} \]

C. 

\[ \text{relationship: } \text{diastereomers} \]

D. 

\[ \text{relationship: } \text{diastereomers} \]
6. (9pts) Fill in the missing reactants, reagents, and products of these substitution reactions. (Assume an S_N2 mechanism.)

\[ \text{NaH} \quad \text{CH}_3\text{I} \quad \text{OH} \quad \text{OCH}_3 \]

7. (6pts) Predict the products of the following E2 eliminations across the C2-C3 bond. What is the stereochemical relationship of the products?

\[ \text{Et} \quad \text{CH}_3 \quad \text{Cl} \quad \text{H}_3\text{C} \quad \text{tBuO}^- \]

8. (10pts) Draw a mechanism for this reaction including all arrows and intermediates. It will involve two substitution reactions.

\[ \text{HI} \quad \text{N} \quad \text{OH} \quad \text{I}^- \]

The two substitutions in the mechanism above are different from each other. Explain how they are different and why the two parts of the reaction have different mechanisms.

\( S_N1 \) vs \( S_N2 \) based on substrate. \( 1^\circ \) center attacked by \( I^- \) directly, \( 3^\circ \) forms carbocation.
9. (12pts) Provide the reagent(s) needed to cause these transformations.

\[ \begin{align*}
\text{OH} & \quad \text{1) TsCl, pyr} \quad H^+ \\
& \quad 2) \text{-OCH}_3 \quad \text{or} \quad \text{CH}_3\text{OH} \\
& \quad \quad \text{or Base} \quad 2) \text{CH}_3\text{X}
\end{align*} \]

10. (12pts) Draw a mechanism with all arrows and intermediates for this E1 reaction:

\[ \begin{align*}
\text{OH} & \quad \text{V H-OSO}_3\text{H} \\
& \quad 2) \text{H}_2\text{O} \quad \rightarrow \quad \text{H}_2\text{O}
\end{align*} \]

Why is the more substituted (Zaitsev) product formed preferentially? (“The product is more stable” is not a complete answer.)

Refer to Hammond and Stability of TS

This reaction is endothermic, but it can still be made to proceed to the right. Explain.

Le Chatelier's principle - removal of H_2O