Before you begin this exam: First: You are allowed to have a simple model set at your seat. Please put away all other materials. Calculators will not be needed. Second: Place your student identification on your desk. A proctor will come around to check everyone’s ID. Third: Read through the entire exam. Your goal, as always, is to score as many points as possible. Do not waste time on problems that you can’t do if there are others that look easy. Fourth: READ EACH QUESTION CAREFULLY. Be sure you answer the question that is asked. Fifth: This exam must be turned in by 8:50 AM SHARP. There will be no extensions, so budget your time carefully.

1. 9 points
2. 12 points
3. 12 points
4. 25 points
5. 12 points
6. 10 points
7. 10 points
8. 4 points
9. 6 points

100 points
1. (9 points) Assign the E,Z-designation to the C=C bonds in the compounds below.

   a)
   \[
   \text{F} \quad \text{Cl}
   \]
   \[
   \text{C=C}
   \]

   b)
   \[
   \text{Br} \quad \text{OCH}_3
   \]

   c)
   \[
   \text{H} \quad \text{O}
   \]

2. (12 points) A reaction energy profile diagram is given below, and several key features are labeled.

   ![Reaction Energy Profile Diagram]

   Provide the most appropriate feature (1-7) from the diagram above to answer the following questions. Note: you are permitted to use one feature (1-7) in more than one of the situations below.

   a) For the reaction A \(\rightarrow\) E, the activation energy for the rate-determining (slow) step is ____.

   b) For the reaction A\(\rightarrow\) E, \(\Delta G\) is ____.

   c) The activation energy for the reaction E\(\rightarrow\) C is ____.

   d) The activation energy for the reaction C \(\rightarrow\) E is ____.
3. (12 points) Four reaction energy profile diagrams (A - D) are given below.

Select the most appropriate diagram (A - D) to match with each of the situations given below. Note: you are permitted to use one diagram (A - D) in more than one of the situations below.

a) An S_N2 reaction with \( K_{eq} = 1 \) ______

b) An E1 reaction that involves a carbocation rearrangement: ______

c) An E2 reaction with \( K_{eq} > 1 \): ___

c) An S_N1 reaction with CH_3OH as the nucleophile: ___

4. (25 points) Each of the reactions below will produce one major product. Draw that (major) product.

a) 

b) 

\[ \text{EtOH} \]
5. (12 points) In the blank to the right of each reaction, indicate the mechanism (S_N_1, S_N_2, E1, E2) involved in the transformation shown.

a)

\[
\text{Br} \quad \text{CH}_3\text{OH}, \Delta \rightarrow \quad \text{OCH}_3
\]

b)

\[
\text{Br} \quad \text{KCN, DMSO} \rightarrow \quad \text{CN}
\]

c)

\[
\text{Br} \quad \text{tBuOH, } \Delta \rightarrow \quad \text{C}
\]
6. (10 points) Treatment of cyclohexene oxide with HBr results in the product shown. Draw a detailed reaction mechanism for this transformation, making sure to use mechanism arrows correctly, and showing the formation and breaking of every bond involved.

\[
\text{HBr} 
\]

7. (10 points) Draw the specific stereoisomer of the product that would be expected to form in each of the reactions below.

a)

\[
\text{CH}_3
\]

b)
8. (4 points) In which of these cases is a carbocation rearrangement likely? (Circle the ones where the rearrangement is likely)

![Diagrams of carbocations]

9. (6 points) cis-1-Bromo-3- tert-butylcyclohexane undergoes E2 elimination at an extremely slow rate. Using a drawing and one sentence, explain why E2 elimination is unfavorable in this molecule.

![Diagram of cis-1-Bromo-3- tert-butylcyclohexane]

END OF EXAM