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 9:20 PM SHARP. There will be no extensions, so budget your time carefully.

1. 9 points _____
2. 9 points _____
3. 15 points _____
4. 25 points _____
5. 6 points _____
6. 8 points _____
7. 8 points _____
8. 10 points _____
9. 10 points _____

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

a) 

\[ \text{Z} \]

b) 

\[ \text{Z} \]

c) 

\[ \text{E} \]

2. (9 points) Treatment of cis-alkenes with a catalytic amount of acid in an inert solvent can lead to isomerization to the more stable trans isomer. Draw a viable mechanism for this transformation. **Do not add any additional reagents.**
3. (15 points) Provide the reagents that would be needed to accomplish the transformations shown. If two steps are needed, be sure that you state “1) reagent A; 2) reagent B.”

a) ![Chemical Structures](image1)

b) ![Chemical Structures](image2)

c) ![Chemical Structures](image3)

4. (25 points) For any five of the reactions below, draw in the expected organic product. Show relevant stereochemistry (syn addition, anti addition, etc), if present. Check the box to indicate which 5 you want graded.

a) ![Chemical Structures](image4)

b) ![Chemical Structures](image5)
c) 
Grade this

\[
\text{Grade this} \quad \begin{array}{c}
\text{1. } \text{O}_3 \\
\text{2. } \text{Zn, HCl}
\end{array}
\]

\[
\begin{array}{c}
\text{Grade this} \\
\text{1. } \text{OsO}_4 \\
\text{2. } \text{NaHSO}_3, \text{H}_2\text{O}
\end{array}
\]

\[
\text{Grade this} \\
\text{1. } \text{BH}_3 \\
\text{2. } \text{NaOH, H}_2\text{O}_2
\]

\[
\text{Grade this} \\
\text{1. } \text{Cl} \quad \text{mCPBA}
\]

\[
\text{Grade this} \\
\text{1. } \text{H}_2, \text{Lindlar Catalyst}
\]

\[
\begin{array}{c}
\text{Grade this} \\
\text{1. } \text{CrO}_3, \text{H}_2\text{SO}_4
\end{array}
\]
5. (6 points) In the mass spectrum of lactic acid, the most intense peak appears at \( m/z = 45 \). Propose a structure for the fragment responsible for the peak at \( m/z = 45 \).

![Lactic acid structure](image)

6. (8 points) In the mass spectrum of aspirin (\( \text{C}_9\text{H}_8\text{O}_4 \)), shown below, what is the mass of the parent ion and what is the mass of the base peak?

![Aspirin mass spectrum](image)

Parent ion \( m/z = 180 \)

Base peak \( m/z = 120 \)
7. (8 points) $^1$H NMR spectroscopy can prove that the Markovnikov product is formed in the reaction below, not the *anti*-Markovnikov product.

a) How many different chemicals shifts should be observed in the $^1$H NMR spectrum of cmpd I? 2

b) What would the integrals be for the different resonances (peaks) in the $^1$H NMR spectrum of cmpd I? 6 to 2 (or 3 to 1)

![Diagram of reaction](image)

8. (10 points) Propose a C$_8$H$_{10}$O structure that is consistent with the IR and $^1$H NMR spectra given below.

![IR spectrum](image)

$^1$H NMR. Integrals are given above the peaks

![NMR spectrum](image)

Additional data on next page....
Problem 8, continued

Expansion of the 2ppm - 4 ppm region:

Structure:

9. (10 points) Propose a structure for a C₆H₁₂O₂ compound that is consistent with the IR and ¹H NMR spectra given below.

Additional data on next page....
Problem 9, continued.

$^1$H NMR. Integrals are given above the peaks

Structure:

![Chemical Structure](image)