Before you begin this exam: 

First: You are allowed to have a simple model set at your seat. Please put away all other materials. 

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: It is critically important that your answers be written in a clear, unambiguous manner. Answers in which your intentions are unclear will not receive credit. 

Fifth: READ THE INSTRUCTIONS FOR EACH PROBLEM. You have until 8:50 to complete this exam. There will be no extensions, so budget your time carefully.

If you wish to have your exam score posted beside your student ID number in the glass case (1st floor, CP Building, behind CP-139) with the exam key, place an ‘X’ in this space. If you do not mark this space, your exam score will not be posted.

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1. (5 points) In the addition of HBr, HCl, HI, Br₂, Cl₂, I₂, borane, and carbenes to alkenes, the \(-\)-electrons function as (circle one)
   a) an electrophile
   b) a nucleophile
   c) an acid
   b) a base

2. (5 points) “Markovnikov” regiochemistry results from (circle one)
   a) the high kinetic reactivity of one carbon of a C=C bond
   b) rapid hydride shifts.
   c) the relative stability of the two possible cation intermediates.
   d) the efficiency of 1,3-dipolar cycloaddition reactions.

3. (5 points) The trans stereochemistry of bromine addition to alkenes results from the formation of a
   a) cyclonium ion.
   b) carbocation.
   c) carbene.
   d) bromonium ion.

4. (5 points) The cis stereochemistry found in hydroboration results from
   a) \textit{cis} addition of borane, followed by retention of configuration during oxidation.
   b) \textit{trans} addition of borane, followed by inversion during oxidation.
   c) \textit{cis} addition of borane, followed by inversion during oxidation.
   d) \textit{trans} addition of borane, followed by retention of configuration during oxidation.
5. (15 points) Draw the expected organic products in each of the following reactions. Be sure to indicate any relevant stereochemistry.

a) 

\[ \text{\begin{align*} &\text{1.} \\
&\text{2. H}_2\text{O}_2, \text{NaOH} \end{align*}} \]

b) 

\[ \text{\begin{align*} &\text{1. OsO}_4 \\
&\text{2. Na}_2\text{SO}_3/\text{H}_2\text{O} \end{align*}} \]

c) 

\[ \text{\begin{align*} &\text{\text{CH}_2\text{N}_2, h[]} \\
&\text{\text{[]} \end{align*}} \]

6. (15 points) Provide the appropriate starting material for the following reactions. In some cases, there may be more than one right answer (showing only one is necessary). Be sure to indicate any relevant stereochemistry in the starting material.

a) 

\[ \text{\begin{align*} &\text{Br}_2 \\
&\text{\text{[]} \end{align*}} \]

b) 

\[ \text{\begin{align*} &\text{\text{[]} \end{align*}} \]
7. (15 points) Supply the reagents required to execute the following transformations. Be careful to specify workup conditions, when appropriate.

a)

![Diagram](image1)

b)

![Diagram](image2)

1. BH₃
2. NaOH, H₂O₂

b)

![Diagram](image3)

1. Cl₂
8. (15 points) “Workup” steps are very important in organic chemistry. In the reaction schemes below, show the species present immediately prior to workup, and show the final product formed after the workup step shown.
(10 points) The bicyclic alkene below undergoes catalytic hydrogenation to produce only one of 2 possible diastereomers. Provide a mechanistic explanation for why isomer A is formed instead of isomer B. Do not exceed the space provided.

The catalyst cannot approach the hindered top side of the C=C bond. As a result, reduction occurs from the lower face exclusively.

(10 points) Propose a viable mechanism for the reaction below. Be sure to pay attention to the appropriate use of arrows.