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: READ EACH QUESTION CAREFULLY. Be sure you answer the question that is asked.  Fifth: This exam must be turned in by 12:50 PM SHARP. There will be no extensions, so budget your time carefully.

1.  6 points ______
2.  30 points ______
3.  8 points ______
4.  12 points ______
5.  12 points ______
6.  10 points ______
7.  10 points ______
8.  12 points ______

Total: ______
1. (6 points) Glycogen is branched polymer composed of glucose units. In the drawing below (a very small piece of glycogen), draw an arrow to each acetal carbon.

2. (30 points). For any SIX of the following, draw the expected major organic product. If you believe that two products (like ortho and para isomers) will be formed in significant amounts, show both. INDICATE WHICH PROBLEMS YOU WANT GRADED.

a) 

\[
\text{Br} \xrightarrow{\text{Ph}_3\text{P}} \xrightarrow{\text{BuLi}} \text{O} 
\]

grade? (Y/N) __

b) 

\[
\text{O} \xrightarrow{\text{TsOH catalyst}} \text{NH} \]

grade? (Y/N) __
c) 

\[
\begin{align*}
\text{grade? (Y/N) } & \quad \text{[Reactions]} \\
\end{align*}
\]

d) 

\[
\begin{align*}
\text{grade? (Y/N) } & \quad \text{[Reactions]} \\
\end{align*}
\]

e) 

\[
\begin{align*}
\text{grade? (Y/N) } & \quad \text{[Reactions]} \\
\end{align*}
\]

f) 

\[
\begin{align*}
\text{grade? (Y/N) } & \quad \text{[Reactions]} \\
\end{align*}
\]

g) 

\[
\begin{align*}
\text{grade? (Y/N) } & \quad \text{[Reactions]} \\
\end{align*}
\]
3. (8 points) Circle the most acidic carboxylic acid in each of the pairs below.

a)

\[
\begin{align*}
&\text{benzyl} \quad \text{bzw. bicarbonyl} \\
&\text{Cl} \quad \text{Cl}
\end{align*}
\]

b)

\[
\begin{align*}
&\text{CH}_3\text{COOH} \\
&\text{HCOOH}
\end{align*}
\]

c)

\[
\begin{align*}
&\text{CH}_3\text{O} \quad \text{CH}_3\text{O} \\
&\text{CO}_2\text{H} \\
&\text{CO}_2\text{H}
\end{align*}
\]

d)

\[
\begin{align*}
&\text{Cl} \quad \text{CH}_3\text{O} \\
&\text{CO}_2\text{H} \\
&\text{Cl} \\
&\text{CH}_3\text{O}
\end{align*}
\]
4. (12 points) Write in the reagents needed to carry out the transformations given below. If two steps are needed, be sure that you give both and designate the separate steps as 1) reagent A and 2) reagent B.

a)

\[
\begin{align*}
\text{O} & \quad \text{O} \\
\text{HO} & \quad \text{HO} \\
\text{CO} & \quad \text{CO} \\
\text{2H} & \quad \text{2H} \\
\text{O} & \quad \text{Br}
\end{align*}
\]

\[
\text{HO} \quad \text{OH}
\]

b)

\[
\begin{align*}
\text{O} & \quad \text{O} \\
\text{CO} & \quad \text{CO} \\
\text{2H} & \quad \text{2H} \\
\text{O} & \quad \text{C}
\end{align*}
\]

\[
\text{C}
\]

c)

\[
\begin{align*}
\text{O} & \quad \text{CO}_2\text{H} \\
\text{CO}_2\text{H} & \quad \text{CO}_2\text{H}
\end{align*}
\]

5. (12 points) Will the reactions shown below produce the product shown? Circle your answer.

a)

\[
\begin{align*}
\text{HO} & \quad \text{Br} \\
\text{1. Mg} & \quad \text{2. C} \\
\text{2. C} & \quad \text{3. H}_2\text{O}, \text{HCl}
\end{align*}
\]

\[
\text{YES} \quad \text{NO}
\]
6. (10 points) Ascorbic acid (vitamin C) is remarkably acidic (pKₐ 4.2) for an organic compound that does not contain a -COOH group. Determine which -OH group is the most acidic and explain why the pKa of that -OH is so low.

Ascorbic Acid
7. (10 points) Show how it is possible to convert the starting material shown into the product shown. Several steps are required, so show the reagents and products from each step along the way to the product. You can use the starting material, any inorganic reagents needed, and any organic reagents of 4 carbons or less. If you use a Grignard, organolithium, or cuprate reagent, show how it is made.
8. (12 points) Draw a detailed, viable mechanism for the following transformation. Do not add any additional reagents. **Pay attention to the proper use of mechanism arrows.**

END OF EXAM