General Instructions:
(i) Use scratch paper at back of exam to work out answers; final answers must be recorded at the proper place on the exam itself for credit. Models are allowed.
(ii) Print your name on each page.
(iii) Please keep your paper covered and your eyes on your own work. Misconduct will lead to failure in the course.

1. (38 points) Show the major product or products expected from each reaction.

(a) \[
\text{\begin{tikzpicture}
  \node (a) at (0,0) {\text{CH}_3\text{CH}_2\text{O}};
  \node (b) at (1,0) {\text{SO}_3};
  \node (c) at (2,0) {\text{H}_2\text{SO}_4};
  \draw[->] (b) -- (c);
\end{tikzpicture}}
\]

(b) \[
\text{\begin{tikzpicture}
  \node (a) at (0,0) {\text{CH}_3};
  \node (b) at (1,0) {\text{CN}};
  \node (c) at (2,0) {\text{CN}};
  \draw[->] (a) -- (b);
\end{tikzpicture}}
\]

(c) \[
\text{\begin{tikzpicture}
  \node (a) at (0,0) {\text{H}};
  \node (b) at (1,0) {\text{H}};
  \node (c) at (2,0) {\text{CH}_3};
  \node (d) at (3,0) {\text{CH}_3};
  \draw[->] (a) -- (b);
  \draw[->] (b) -- (c);
  \draw[->] (c) -- (d);
  \node (e) at (1,-1) {\text{1) O}_3};
  \node (f) at (2,-1) {\text{2) Zn}^0, \text{AcOH}};
\end{tikzpicture}}
\]

(continued on next page)
1. (cont.)

(d) \[ \text{H} \quad \text{Cl}_2 \quad \text{CCl}_4 \]
(One enantiomer)

(e) \[ \text{1) Hg(OAc)}_2, \text{H}_2\text{O/THF} \quad \text{2) NaBH}_4 \]

(f) \[ \text{CH}_3 - \text{C} = \text{C} - \text{CH}_2\text{CH}_3 \quad \text{1) Li}^\circ, \text{NH}_3 \text{ (llq.)} \quad \text{2) H}_2\text{O} \]

(g) \[ \text{HCl} \]
2. (48 points) Show the reagents required to convert the starting molecule to the indicated product. If necessary, be sure to differentiate clearly between distinct steps, by using "1)," "2)," etc. over the arrow.

(a) 
\[
\text{CH}_3
\]

(b) 
\[
\text{CH}_3
\]

(c) 
\[
\text{H}
\]

(d) 
\[
\text{H} \quad \text{CH}_3
\]

(continued on next page)
2. (cont.)

(e) \[
\begin{align*}
\text{Cyclic structure} & \rightarrow \\
\text{Linear structure} & 
\end{align*}
\]

(f) \[
\begin{align*}
\text{Linear structure} & \rightarrow \\
\text{Linear structure} & 
\end{align*}
\]

(g) \[
\begin{align*}
\text{Linear structure} & \rightarrow \\
\text{Linear structure} & 
\end{align*}
\]

(h) \[
\begin{align*}
\text{Linear structure} & \rightarrow \\
\text{Linear structure} & 
\end{align*}
\]
3. (16 points) For each pair of reactions below, circle the one that you would expect to be more thermodynamically favorable. Briefly explain your reasoning.

(a) \[
\begin{align*}
&\text{Catalyst} \\
\end{align*}
\]

(b) \[
\begin{align*}
&\text{OCH}_3 \quad \text{Br} \\
\end{align*}
\]
4. (16 points) For each pair of structures below, circle the one that you would expect to be more stable. Briefly explain your reasoning.

(a) 

(b) 

vs. 

vs. 

Name __________________________
5. (8 points) Draw the structure of the starting material that provides the alkene shown below, and no other products, upon treatment with tBuONa in tBuOH.

6. (8 points)

(a) Redraw the molecule shown below in such a way that the configurations of the two chiral centers are clearly indicated (R for the carbon bearing bromine, and S for the carbon bearing methoxy).

(b) How many stereoisomers (diastereomers/enantiomers) are there that correspond to the line drawing above? Be sure to include the isomer you drew above in your counting!
7. (6 points) For each of the alkenes shown below, indicate the configuration (Z or E).

8. (12 points) When the alkyl bromide shown below is treated with tBuONa in tBuOH, there is no reaction. Briefly explain this observation, using structural drawings to illustrate your reasoning.
9. (28 points) Provide a mechanism for each reaction below (include all important resonance structures of intermediates).

(a)
9. (cont.)

(b) 
\[
\begin{align*}
\text{CH}_2 & \quad \text{HCl} \\
\text{CH} & \quad \text{Cl}
\end{align*}
\]

(c) 
\[
\begin{align*}
\text{Br} & \quad \text{NaCN} \\
\text{DMSO} & \quad \text{CN}
\end{align*}
\]

(one stereoisomer only) (one stereoisomer only)
10. (20 points) In the reaction shown below, it is impossible to isolate the product containing only one ethyl group, even if only 1 equiv. of CH\textsubscript{3}CH\textsubscript{2}Cl is used. Provide an energy diagram for this process, labelling all intermediates along the path from starting material to product. Show the key energy difference on this diagram that indicates why the reaction cannot be stopped after one ethyl has been added to the ring.
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Total: / 200
### Periodic Table of the Elements

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[Note: The table continues with additional elements not shown here.]