General Instructions:
Use scratch paper at the back of the exam to work out answers. Final answers must be recorded at the proper place on the exam itself for credit.
Print your name and ID # on each page.
Please keep your paper covered and your eyes on your own work.
Academic misconduct will lead to failure in the course.

1. (20 pts.) Write the major product(s) of the following reactions showing stereochemistry in 3-D where necessary and all stereoisomers which are formed.

(a) \[ \text{Br}_2 \rightarrow \text{light monobromination} \]

(b) \[ \text{Cl}_2 \rightarrow \text{CH}_2\text{Cl}_2 \]

(c) \[ \text{NaOCH}_2\text{CH}_3 \]

(e) \[ \text{NaCN} \]
2. (12 pts.) Write the major product(s) of the following reactions showing stereochemistry in 3-D and all stereoisomers. Label the starting material and products as chiral or achiral.

(a) \[
\begin{align*}
&\text{CH}_3 \quad \text{Br} \\
&\text{CH}_3 \quad \text{H} \\
\end{align*}
\]

\[\text{NaOCH}_3\]

(b) \[
\begin{align*}
&\text{Br} \\
&\text{1. Hg(OAc)}_2, \text{H}_2\text{O} \\
&\text{2. NaBH}_4, \text{NaOH} \\
\end{align*}
\]

3. (7 pts.) Show how you would accomplish the following synthesis. Show all isolated intermediate products and reagents over the arrows. More than one step is required.

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

\[
\begin{align*}
&\text{Br} \\
\end{align*}
\]
4. (16 pts.) Circle the correct structure.

(a) The alkyl halide which will react **most rapidly** with ethanol.

(b) The compound which has the **highest** $\Delta H^\circ$ (bond dissociation energy) of the indicated C-H bond.

(c) The alkyl bromide which will undergo dehydrobromination **most rapidly**.

(d) The **meso** compound(s).

5. (4 pts.) Label the stereogenic centers as R or S.
5. (10 pts.) Draw all the elimination products formed in the following reaction. Circle the ones that are optically active. The starting material is optically active.

![Reaction Diagram]

6. (4 pts.) Draw the structure of (2R,3S,4R)-3,4-dimethyl-2-hexanol in 3-D.

7. (8 pts.) There are two dicarboxylic acids with formula $\text{HO}_2\text{CCH}=$CH$\text{CO}_2\text{H}$. One dicarboxylic acid is called maleic acid; the other is called fumaric acid. On treatment with $\text{Br}_2$, fumaric yields a meso dibromodiacid and maleic acid yields a racemic mixture of ($R$,R)-dibromodiacid and ($S$,S)-dibromodiacid. Write stereochemical formulas in 3-D for all 5 dicarboxylic acids in the boxes below.

![Molecular Structures]
8. (12 pts.) (a) Draw the cis and the trans 1-bromo-4-tert-butylcyclohexanes each in their most stable chair conformation. Show the hydrogens on the carbons that have substituents.

(b) Which isomer will undergo E₂ elimination most rapidly with NaOCH₃ and why?

(c) Draw the transition state for this E₂ reaction using the isomer that reacts most rapidly.

9. (7 pts.) Draw the mechanism of the following reaction. Show all intermediates and electron-pushing arrows.