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. (18 pts.) Write the major product(s) of the following reactions showing stereochemistry in 3-D where necessary and all stereoisomers. Indicate if the reaction is an oxidation (O), reduction (R) or neither (N).

(a) \[
\text{HO-CH} \quad \text{CrO}_3, \text{H}_2\text{SO}_4, \text{xs} \\
\quad \text{H}_2\text{O} \\
\text{HO-CO} \quad \text{O} \\
\text{R} \\
\text{N}
\]

(b) \[
\text{H-H-H-H} \\
\quad \text{NH}_2\text{CH}_3 \\
\text{OH} \\
\text{O} \\
\text{R} \\
\text{N}
\]

(c) \[
\text{Ph-MgBr} \\
\quad \text{CH}_3\text{CH}_2\text{OH} \\
\text{C} \\
\text{O} \\
\text{R} \\
\text{N}
\]
2. (20 pts.) Write the major product(s) of the following reactions showing stereochemistry in 3-D where necessary and all stereoisomers.

(a) \[
\begin{align*}
\text{HgSO}_4 & \quad \text{H}_2\text{SO}_4, \text{H}_2\text{O} \\
\end{align*}
\]
\[
\text{H}_2\text{O}
\]

(b) \[
\begin{align*}
\text{HBr} & \quad \text{H}_2\text{O} \\
\end{align*}
\]

(c) \[
\begin{align*}
\text{OH} & \quad 1. \text{MsCl} \\
\text{2. NaSCH}_3 \\
\end{align*}
\]

(d) \[
\begin{align*}
\text{HI} & \quad 1 \text{ equiv} \\
\end{align*}
\]
3. (20 pts.)

(a) Circle the strongest acid and put a box around the weakest acid.

\[
\text{SH} \quad \text{NH}_2 \quad \text{OH} \quad \text{H} = \text{H}
\]

(b) Circle the strongest base. Put a box around the weakest base.

\[
\text{H} = \text{H} \quad \text{NH}_2 \quad \text{OH}
\]

(c) Circle the diastereotopic hydrogens and put a box around the enantiotopic hydrogens.

\[
\text{O} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H}
\]

(d) Circle the alkene most reactive toward electrophilic addition. Put a box around the least reactive alkene.

\[
\text{Cyclohexane} \quad \text{Cyclohexene} \quad \text{Bromocyclohexene} \quad \text{Cyclohexane}
\]

(e) Circle the reagent that is not an alkylating agent.

\[
\text{Br} \quad \text{OH} \quad \text{O}^+ \quad \text{SO}_2 \text{O}
\]
4. (10 pts.) Show the complete mechanism for the following reaction. Include all intermediates and electron-pushing arrows and all formal charges.

5. (10 pts.) You wish to prepare (R)-3-hexanol and (S)-3-hexanol and have available the two epoxides shown below. Choose the appropriate epoxide for each synthesis and show the reagents necessary to carry out each transformation. Label the products as (R) or (S)
6. (12 pts.) Show how you would accomplish the following syntheses. Write the reagents over the arrows. Number the reagents that cannot be mixed.

(a) $\text{H} = \text{H}$

(b) $\text{Br} \rightarrow \text{Br}$

7. (5 pts.) Show the reagents needed to make the following ether using the Williamson ether synthesis.

8. (5 pts.) Show the reagents needed to make the following ether using the alkoxymercuration-demercuration method.