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) \[
\text{HO} \quad \text{H} \\
\text{C} \quad \text{O} \\
\text{H} \quad \text{H} \\
\text{C} \quad \text{O} \\
\text{H} \quad \text{H}
\]
\[
\text{CrO}_3, \text{H}_2\text{SO}_4, \text{xs} \quad \text{H}_2\text{O}
\]
\[
\rightarrow \\
\text{O} \quad \text{R} \quad \text{N}
\]

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

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

(a) \[ \text{HgSO}_4 \] \[ \text{H}_2\text{SO}_4, \text{H}_2\text{O} \]

(b) \[ \text{HBr} \]

(c) \[ \text{1. MsCl} \] \[ \text{2. NaSCH}_3 \]

(d) \[ \text{HI} \] \[ \text{1 equiv} \]
3. (20 pts.)

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

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

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

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

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

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

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

\[ \text{cyclohexene} \quad \text{cyclohexene} \quad \text{cyclohexene} \quad \text{cyclohexene} \]

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

\[ \text{Br} \quad \text{OH} \quad \text{O}^+ \quad \text{O} \]

\[ \text{SO}_2 \text{O} \quad \text{O} \]

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. (10 pts.) Show how you would accomplish the following syntheses. Write the reagents over the arrows. Number the reagents that cannot be mixed.

(a) \[ \text{H} \rightarrow \text{CH}_3 \text{CH}_2 \text{CH}_2 \text{Cl} \]

(b) \[ \text{CH}_3 \rightarrow \text{CH} = \text{CH}_2 \]

7. (6 pts.) Show the reagents needed to make the following ether using the Williamson ether synthesis.

8. (6 pts.) Show the reagents needed to make the following ether using the alkoxymercuration-demercuration method.