1. (24 pts.) Write the product(s) of the following reactions showing stereochemistry in 3-D where necessary and all stereoisomers. Label the products as optically active (O), achiral (A) or racemic (R).

(a) 

(b) 

(c) 

(d) 

(e) 

H_2SO_4

H_2O

HBr

Br_2

hv

H_2

Pd/C

O

A
2. (16 pts.) Choose the alkyl halides from the list above to meet each criterion below.

(a) the compound(s) that can exist as enantiomers $D, E$

(b) the compound(s) that can exist as diastereomers $E$

(c) the compound that gives the fastest $S_N2$ reaction with sodium methoxide $A$

(d) the compound that is least reactive to sodium methoxide in methanol $C$

(e) the compound(s) that give only one alkene in the E2 reaction $A$

(f) the compound(s) that give an E2 but no $S_N2$ reaction $B$

(g) the compound(s) that undergo an $S_N1$ reaction to give rearranged product(s) $(C, E)$, $D, E$

(h) the compound that gives the fastest $S_N1$ reaction $B$
3. (20 pts.) Circle the correct structure.

(a) Circle the structures that have the S configuration at the stereogenic center.

(b) Circle the most basic compound and put a box around the least basic compound.

(c) Circle the compounds that are chiral.

(d) Circle the reagents which give a nonstereospecific reaction upon addition to a double bond.

Br₂/CH₂Cl₂  H₂/Pd/C  H₃O⁺/H₂O  BH₃/THF

(e) Circle the alkyl halide which will give the highest ratio of E₂/S₂ when treated with NaOCH₂CH₃/CH₃CH₂OH.
4. (8 pts.) Draw the isomers of 1,2,3-trimethylcyclohexane, first in wedge-dash format and then in their most stable chair conformations.

![Wedge-dash representations of isomers]

5. (4 pts.) Name the following compound.

\[(S)-3\text{-methyl}-2\text{-cyclohexen-1-ol}\]

2. (10 pts.) Write the product(s) of the following reactions showing stereochemistry in 3-D including stereoisomers.

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

(b) \[\begin{align*}
\text{Br} & \quad \text{NaOCH}_2\text{CH}_3 \\
\end{align*}\]
7. (8 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. Working backwards often helps.

(a) 

\[
\text{Br}_2 \xrightarrow[\text{hv}]{} \text{OH} + \text{OH}
\]

\[
1. \text{BH}_3, \text{THF} \\
2. \text{H}_2\text{O}_2, \text{NaOH}
\]

8. (10 pts.) Draw the mechanism of the following reaction. Show all intermediates and electron-pushing arrows.

\[
\text{H}_2\text{SO}_4 \rightarrow \text{Ar}
\]

or \text{ph} can migrate