1. (25 points) a) Give the products or reagents needed (A, B, C, and D)

1. BH₃

O

O H O H

A

1. H₂O₂, OH

B

C

2. H₂O

D

b) Draw the intermediate for reaction A. Is the reaction Markovnikov oriented? Why or why not? Does the reaction occur syn or anti? Why?

2. (20 points) 1,2-Dimethylcyclobutene reacts with OsO₄ / NaHSO₃ to give diol E.

a) Draw all possible stereoisomers of E and label all stereocenters (R or S). What are their relationships to each other?

b) Which stereoisomers could have come from this reaction?

c) If the rotation of the (1S, 2S) isomer is -23°, predict the rotations of the other stereoisomers.
3. (20 points) Pulegone reacts with Hydrogen in the presence of Palladium catalyst to give menthone F, a precursor to the flavor menthol.

![Menthone Reaction]

a) Draw all possible stereoisomers of F, label all stereocenters (R or S).
b) Which stereoisomers are possible from this reaction?
c) If the rotation of the (2S, 5R) isomer is $-20^\circ$, predict the rotations of the other stereoisomers

4. (25 points) For the reactions below

![Cyclopentene Reactions]

a) Draw the intermediates and products. Explain why each product is formed preferentially.
b) Draw fully labelled energy diagrams for each reactions as a 2 step exothermic process. Label activation energies, overall free energy, transition states, intermediates, starting materials and products.

5. (10 points) 1,2-Dimethylcyclohexene reacts with Br₂ to give dibromide G. G then reacts with KOH to give H.

a) Draw G and H
b) Calculate the degrees of unsaturation from the molecular formula of H.