Before you begin this exam: First: You are allowed to have a simple model set at your seat. Please put away all other materials. Calculators will not be needed. Second: Place your student identification on your desk. A proctor will come around to check everyone’s ID. Third: Read through the entire exam. Your goal, as always, is to score as many points as possible. Do not waste time on problems that you can’t do if there are others that look easy. Fourth: READ EACH QUESTION CAREFULLY. Be sure you answer the question that is asked. Fifth: This exam must be turned in by 8:50 AM SHARP. There will be no extensions, so budget your time carefully.

1. 8 points _____
2. 10 points _____
3. 8 points _____
4. 8 points _____
5. 12 points _____
6. 9 points _____
7. 12 points _____
8. 12 points _____
9. 15 points _____
10. 6 points _____

100 points _____
1. (8 points) Draw structures that correspond to these names. Do not indicate stereochemistry.
   a) 2-Bromo-2-chlorobutane

   b) 2,3-Dimethylpentane

2. (10 points) Draw 5 valid isomers of C$_7$H$_{14}$.
   i.  
   ii.  
   iii.  
   iv.  
   v.  
3. (8 points) Convert the Newman projection below into a 'zig-zag' drawing, taking care to preserve the stereochemistry. The skeleton of the zig-zag drawing is provided - draw in the missing groups in the correct positions.

4. (8 points) Draw each of the following in their most favorable (lowest energy) chair conformation. **Be very sure that it is clear from your drawings which groups are axial and which are equatorial. No credit will be given if the orientation is ambiguous.**

   a)

   ![Image](image-a)

   b)

   ![Image](image-b)
5. (12 points) Below is a set of Newman projections (two staggered, two eclipsed), looking down the C3-C4 bond of 3-methylpentane. Construct a rotational energy profile diagram for rotation around this bond. You need to show the relative energies (not specific numbers) of the 4 conformations shown and to construct the curve between those energies.

6. (9 points) Label each of the following compounds as chiral or meso, as appropriate.
7. (12 points) Assign the $R, S$-designation to the three stereogenic centers in the terpene known as menthol (shown below).

![Menthol](image)

8. (12 points) To correctly describe the relationship between each pair structures show below, write “identical,” “structural isomers,” “enantiomers,” “diastereomers,” or “conformational isomers,” as appropriate.

a) 

b) 

c) 

d)
9. Naproxen ("Aleve") is a common over-the-counter anti-inflammatory drug. The $S$-enantiomer is effective, the $R$-enantiomer is not. The $[\alpha]_D$ of the $S$-enantiomer is $+50^\circ$.

   a) (3 points) Is the $S$-enantiomer levorotatory or dextrorotatory? ___________

   b) (6 points) What is the ee of a sample where the measured $[\alpha]$ is $+25^\circ$?

   c) (6 points) In a sample of Naproxen where the ee is 64% and the optical rotation in the $(+)$ direction, what fraction (what percentage) of the sample is the desired $S$-enantiomer?

10. (6 points) Examine the reactions below and classify each one as either a substitution reaction, an addition reaction, or as an elimination reaction.

   a)

   \[
   \begin{align*}
   \text{I} & \quad \text{H}_2\text{O} \\
   \text{Cyclohexene} & \quad \text{OCH}_3
   \end{align*}
   \]

   b)

   \[
   \begin{align*}
   \text{HO} & \quad \text{HO} \\
   \text{Cyclohexane} & \quad \text{O} + \text{H}_2\text{O}
   \end{align*}
   \]

   c)