Midterm Review

1. Locate the four stereogenic centers in aliskiren, a drug introduced in 2007 for the treatment of hypertension.

![Aliskiren structure](image)

2. Label each pair of compounds as constitutional isomers, stereoisomers, or not isomers of each other.

   a. ![Cyclopentane](image) and ![Ethyl acetate](image)
   b. ![Propenal](image) and ![Cyclopentanone](image)
   c. ![4-Methylcyclohexane](image) and ![6-Methylcyclohexane](image)
   d. ![2-Methylcyclopentane](image) and ![3-Methylcyclopentane](image)

3. Rank the following groups in order of decreasing priority.
   a. -COOH, -H, -NH₂, -OH  
   b. -H, -CH₃, -Cl, -CH₂Cl  
   c. -CH₂CH₃, -CH₃, -H, -CH(CH₃)₂  
   d. -CH=CH₂, -CH₃, -C≡CH, -H
Midterm Review

4. Give the IUPAC name for each compound, including the R, S designation for each stereogenic center.
   a. 
   b. 
   c. 

5. Draw a meso compound for each of the following molecules.
   a. BrCH₂CH₂CH(Cl)CH(Cl)CH₂CH₂Br
   b. 
   c. 

6. (a) Label the four stereogenic centers in sorbitol as R or S. (b) How are sorbitol and A related? (c) How are sorbitol and B related?
   Sorbitol
   A
   B
Midterm Review

7. Draw all possible constitutional and stereoisomers for a compound of molecular formula C₆H₁₂ having a cyclobutane ring and two methyl groups as substituents. Label each molecule as chiral or achiral.

8. Artemisinin and Mefloquine are widely used antimalarial drugs.

   a. Locate the stereogenic centers in both drugs.
   b. Label each stereogenic center in Mefloquine as R or S.
   c. What is the maximum number of stereoisomers possible for Artemisinin?
   d. Can two molecules of Artemisinin intermolecularly Hydrogen bond to each other?

9. Pure MSG, a common flavor enhancer, exhibits a specific rotation of +24. (a) Calculate the ee of the solution whose [α] is +10. (b) If the ee of a solution of MSG is 80%, what is [α] for this solution?
10. Classify each transformation as substitution, elimination, or addition.

A.

\[
\begin{align*}
\text{CO} & \quad \text{OH} \\
\text{CH}_3\text{CH}_2\text{C} & \quad \text{CH}_3\text{CH}_2\text{OH}
\end{align*}
\]

B.

\[
\begin{align*}
\text{HO} & \quad \text{O} \\
\text{HO} & \quad \text{O} \\
\text{C}_7 & \quad \text{C}_7
\end{align*}
\]

11. Use full-headed or half-headed curved arrows to show the movement of electrons in each reaction.

A.

\[
\begin{align*}
\text{CH}_3\text{CH}_3 & \quad \text{O} \\
\text{CH}_3\text{CH}_3 & \quad \text{O} \\
\text{C}_7 & \quad \text{C}_7
\end{align*}
\]

B.

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{Br} & \quad \text{O} \\
\text{CH}_3\text{CH}_2\text{OH} & \quad \text{Br} \\
\text{C}_7 & \quad \text{C}_7
\end{align*}
\]

C.

\[
\begin{align*}
\text{} & \quad \text{Br} \\
\text{} & \quad \text{Br} \\
\text{C}_7 & \quad \text{C}_7
\end{align*}
\]
12. Use the image below as a reference for A and B.

A. Draw in the curved arrows to show how A is converted to B in Step [1].

B. Identify X using the curved arrows drawn for Step [2].

13. a) Draw in curved arrows to illustrate how C is converted to D in Step [1]. (b) Identify Y, the product of Step [2], using the curved arrows that are drawn on compound D.

14. Rank each of the following bonds in order of increasing bond dissociation energy a.
15. Homolysis of the indicated C–H bond in propene forms a resonance-stabilized radical. Draw the two possible resonance structures for this radical and show arrows.

![Resonance structures](image)

16. Given each value, determine whether the starting material or product is favored at equilibrium
   a. $K_{eq} = 16$
   b. $\Delta G^\circ = 2.0 \text{ kJ/mol}$
   c. $\Delta H^\circ = 8.0 \text{ kJ/mol}$
   d. $\Delta S^\circ = -8 \text{ J/(K \cdot mol)}$

17. As we learned in Chapter 4, monosubstituted cyclohexanes exist as an equilibrium mixture of two conformations having either an axial or equatorial substituent.
a. Which R shows the highest percentage of equatorial conformation at equilibrium?

b. Which R shows the highest percentage of axial conformation at equilibrium?

c. For which R is $\Delta G^\circ$ most negative?

18. Calculate $\Delta H^\circ$ for each reaction

a. \[ \text{CH}_3\text{CH}_3 + \text{Br}_2 \rightarrow \text{CH}_3\text{CH}_2\text{Br} + \text{HBr} \]

b. \[ \text{HO}^- + \text{CH}_4 \rightarrow \cdot\text{CH}_3 + \text{H}_2\text{O} \]
19. Consider the following energy diagram for the overall reaction: (CH₃)₃COH + HI → (CH₃)₃Cl + H₂O.

a. How many steps are in the reaction mechanism?

b. Label the Ea and ∆H° for each step, and the ∆H°overall for the reaction.

c. Draw the structure of the transition state for each step and indicate its location on the energy diagram.

d. Which step is rate-determining? Why?
20. The following is a concerted, bimolecular reaction

\[ \text{CH}_3\text{Br} + \text{NaCN} \rightarrow \text{CH}_3\text{CN} + \text{NaBr}. \]

a. What is the rate equation for this reaction?

b. What happens to the rate of the reaction if [CH3Br] is doubled?

c. What happens to the rate of the reaction if [NaCN] is halved?

d. What happens to the rate of the reaction if [CH3Br] and [NaCN] are both increased by a factor of five?

**Review Problems:**

1. (a) Draw the anti and gauche conformations for ethylene glycol (HOCH₂CH₂OH) (b) Ethylene Glycol is unusual in that the gauche conformation is more stable than the anti conformation. Offer an explanation.

2. Draw four additional resonance structures for the following cation.

3. Convert each molecule into a skeletal structure.

\[ (\text{CH}_3)_3\text{C(CH}_2)_5\text{CH}_3 \]
4. Two pKa values are reported for malonic acid, a compound with two COOH groups. Explain why one pKa is lower and one pKa is higher than the pKa of acetic acid (CH3COOH, pKa = 4.8).

\[
\begin{align*}
\text{HO} & \quad \text{OH} \\
\text{malonic acid} & \quad \text{pK}_a = 2.86 \\
\text{HO} & \quad \text{CO}_{2}^- \\
\text{pK}_a = 5.70 & \\
\text{CO}_{2}^- & \\
\end{align*}
\]

5. Which of the given 1,3,5-trimethylcyclohexane isomers is more stable? Explain your choice.

or

Important Concepts from Chapters 5/6:
- R and S configuration (rotating molecules when H is not in the back)
- Drawing all possible stereoisomers for a given compound
- Chiral, achiral, and meso compounds
- Difference between conformers, enantiomers, diastereomers, and constitutional isomers
- Cis and trans isomers
- Racemic mixtures, enantiomeric excess, specific rotation (know the equations)
- L and D compounds (plane polarized light)
- Classifying substitution, elimination, and addition reactions
- Drawing curved arrows
- Heterolytic and homolytic cleavage
- Two electron arrows, one electron arrows
- Cation, anion, and radicals
- Enthalpy of reaction
- Keq
- Gibbs free energy
- Endothermic and exothermic reactions