### Academic Honesty Policy

Academic honesty is strictly enforced on quizzes, exams, and other aspects of this course. Academic dishonesty will result in a failing grade in the class and a letter in the student's file. Activities constituting academic dishonesty include:

**Cheating**
- Copying from others during an examination.
- Communicating exam answers with other students during an examination.
- Offering another person's work as one's own.
- Taking an examination for another student or having someone take an examination for oneself.
- Tampering with an examination after it has been corrected, then returning it for more credit.
- Using unauthorized materials, prepared answers, written notes, or concealed information during an examination.

**Dishonest Conduct**
- Stealing or attempting to steal an examination or answer key from the instructor.
- Allowing another student to copy off of one's own work during a test.

**Collusion**
- Any student who knowingly or intentionally helps another student perform any of the above acts is subject to discipline for academic dishonesty.

I understand and will abide by this academic honesty policy: ____________________________ (signature)
1. (21 points)

a. Rank the following in order of increasing rate of reaction with sodium cyanide (NaCN): ___ < ___ < ___

(a) CH₃F
(b) CH₃Cl
(c) CH₃I

b. Rank the following in order of increasing rate of reaction with iodomethane (CH₃I): ___ < ___ < ___

(a) CH₃CO₂⁻ Na⁺
(b) CH₃CH₂O⁻ Na⁺
(c) CH₃CH₂OH

c. Rank the following in order of increasing rate of reaction with sodium azide (NaN₃): ___ < ___ < ___

(a) 1-bromopropane
(b) 3-bromopropene (CH₂=CHCH₂Br)
(c) 2-methyl-1-bromopropane

d. Rank the following in order of increasing equilibrium constant: ___ < ___ < ___

(a) HC≡CH + NH₂⁻ ↔ HC≡C⁻ + NH₃
(b) H₂C=CH₂ + t-BuO⁻ ↔ H₂C≡CH⁻ + t-BuOH
(c) CH₃CH₂OH + OH⁻ ↔ CH₃CH₂O⁻ + H₂O

e. Rank the following in order of increasing stability: ___ < ___ < ___

(a) CH₃CH₂⁺
(b) (CH₃)₃C⁺
(c) (CH₃)₂CH⁺

f. Rank the following in order of increasing boiling point: ___ < ___ < ___

(a) CH₃CO₂CH₂CH₃
(b) CH₃CH₂CH₂CH₂CH₂CH₃
(c) CH₃CH₂CH₂CO₂H

g. Rank the following in order of increasing energy: ___ < ___ < ___

(a) the relative energy of axial methylcyclohexane
(b) the relative energy of gauche butane
(c) the relative energy of eclipsed ethane
2. Write the missing reactants, reagents, and products in the boxes. If NO REACTION OCCURS, write N.R. (18 points)

\[(\text{CH}_3)_3\text{N} + \quad \rightarrow \quad \text{CH}_3\text{CH}_3\text{N}^+\text{CH}_3\text{I}^-\]

\[\text{Cl} \quad \text{KO-t-Bu} \quad \text{t-BuOH} \rightarrow \quad \]

\[\text{SH} \quad \text{NaOH} \quad \text{CH}_3\text{CH}_2\text{I} \rightarrow \quad \]

\[\text{OH} \quad \text{NaI} \quad \text{acetone} \rightarrow \quad \]

\[\text{OH} \quad \text{NaI} \quad \text{acetone} \rightarrow \quad \]

\[\text{CH}_3\text{CO}_2\text{Na}^- \quad \rightarrow \quad \text{CH}_3\text{CO}_2\text{Na}^+ \quad (+ \text{H}_2\text{O})\]

\[\text{CH}_3\text{CO}_2\text{Na}^- \quad \text{Na}^+ \quad \rightarrow \quad \text{CH}_3\text{CO}_2\text{CPh}_3 \quad (+ \text{NaCl})\]
3. Write the structure of a compound that meets the criteria indicated below. (24 points)

a. $(1R,2R)$-1,2-dichlorocyclohexane:

b. meso-1,3-dimethylcyclopentane:

c. $(R)$-3-phenyloctane:

d. the enantiomer of the sex hormone estradiol:

\[
\begin{array}{c}
\text{estradiol} \\
\end{array}
\]

e. trans-1-chloro-4-methylcyclohexane:

f. A diastereomer of the marine natural product halomon:

\[
\begin{array}{c}
\text{halomon} \\
\end{array}
\]
4. Briefly explain the following (in two sentences or less): (20 points)

a. Reaction of sodium ethoxide with bromocyclopentane is not a good way to prepare cyclopentyl ethyl ether:

\[ \text{CH}_3\text{CH}_2\text{O}^- \text{ Na}^+ \quad \text{Br} \quad \text{OCH}_2\text{CH}_3 \]

sodium ethoxide \hspace{2cm} bromocyclopentane \hspace{2cm} cyclopentyl ethyl ether

b. Reaction of 3-bromohexane (CH\textsubscript{3}CH\textsubscript{2}CHBrCH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{3}) with potassium tert-butoxide (KO-t-Bu) is not a good way to prepare 3-hexene (CH\textsubscript{3}CH\textsubscript{2}CH=CHCH\textsubscript{2}CH\textsubscript{3}).

c. Optically active tertiary alkyl halides racemize much more rapidly than optically active secondary alkyl halides.

d. Dimethyl sulfoxide, (CH\textsubscript{3})\textsubscript{2}SO, is miscible (dissolves completely) with water but not with hexane.

e. The stereoisomer of 2,3-butanediol shown below does not rotate plane polarized light.

\[ \text{OH} \quad \text{OH} \]
5. Write curved-arrow mechanisms for the following reactions. Make sure to show all intermediates, charges, and lone pairs of electrons. (24 points)

a. Formation of tetrahydropyran from 5-chloro-1-pentanol:

\[
\text{Cl} \quad \text{O} \quad \text{H} + \quad \text{H}^- \quad \text{O} \quad \text{H} \quad \rightarrow \quad \text{O}
\]

mechanism:

b. Formation of 1-methylcyclohexene and 1-ethoxy-1-methyloclohexane by solvolysis of 1-chloro-1-methyloclohexane in ethanol:

mechanism for formation of 1-methylcyclohexene:

mechanism for formation of 1-ethoxy-1-methyloclohexane:
6. 2-Chlorotetrahydropyran undergoes S$_N$1 substitution much faster than chlorocyclohexane. (The reactions are shown below, with the generic nucleophile Nu$^-$.) (18 points)

\[
\begin{align*}
\text{2-chlorotetrahydropyran} & \quad + \quad \text{Nu}^- & \rightarrow & \quad \text{Nu} \quad + \quad \text{Cl}^- \\
\text{chlorocyclohexane} & \quad + \quad \text{Nu}^- & \rightarrow & \quad \text{Nu} \quad + \quad \text{Cl}^- 
\end{align*}
\]

a. Write a curved-arrow mechanism, illustrating the S$_N$1 substitution of 2-chlorotetrahydropyran. Make sure to show all intermediates, charges, and lone pairs of electrons.

b. Explain why 2-chlorotetrahydropyran undergoes S$_N$1 substitution much faster than chlorocyclohexane.

e. Using the reaction energy diagrams shown below, show that 2-chlorotetrahydropyran undergoes S$_N$1 substitution much faster than chlorocyclohexane.
7. Treatment of one diastereomer of \((1R,2S)-1\)-bromo-1,2-diphenylpropane with sodium ethoxide generates \((E)-1,2\)-diphenylpropene by \(E_2\) elimination, while treatment of \((1S,2S)-1\)-bromo-1,2-diphenylpropane with sodium ethoxide generates \((Z)-1,2\)-diphenylpropene. (15 points)

\[
\begin{align*}
\text{(1R,2S)-1-bromo-1,2-diphenylpropane} & \quad \xrightarrow{\text{NaOEt}} \quad \text{(E)-1,2-diphenylpropene} \\
\text{(1S,2S)-1-bromo-1,2-diphenylpropane} & \quad \xrightarrow{\text{NaOEt}} \quad \text{(Z)-1,2-diphenylpropene}
\end{align*}
\]

a. Draw a Newman projection of the \((1R,2S)\)-diastereomer in which the two phenyl groups are antiperiplanar.

Can loss of HBr occur in an \textit{antiperiplanar} fashion in this conformer?___________

b. Draw a Newman projection of the \((1S,2S)\)-diastereomer in which the two phenyl groups are antiperiplanar.

Can loss of HBr occur in an \textit{antiperiplanar} fashion in this conformer?___________

c. Draw a Newman projection of the \((1S,2S)\)-diastereomer in which the H and Br that are lost are antiperiplanar.
8. (10 points)

a. Write the product(s) of the following $E_2$ elimination.

\[
\begin{array}{c}
H \quad D \\
\text{Cl} \\
\text{H} \quad D \\
\end{array}
\quad \xrightarrow{\text{KO-t-Bu}} \quad \text{t-BuOH}
\]

b. Draw the cyclohexane ring in the chair conformation that allows the formation of the product(s) and clearly show the stereochemical relationship between the two groups that are lost.

PLEASE REVIEW THE ACADEMIC HONESTY STATEMENT ON PAGE 1 AND SIGN IT IF YOU ARE ABLE.

Please note that signatures and handwriting will be compared with those on quizzes and the midterm exam.