Summer 16 Organic I Final Exam 100pts (graded as 150pts)

Name ____________________________

(1 a-j) are TRUE/FALSE (10pts)

a) Chiral molecules have non-superimposable mirror images.

b) $S_N 1$ and $E_1$ reactions both proceed through carbocation intermediates.

c) A triple bond has two $\pi$ bonds and one $\sigma$ bond.

d) Cyclopropane has more ring strain than cyclobutane.

e) Cahn, Ingold and Prelog created the rules for assigning R or S to a chiral center.

f) Cyclohexanol is a chiral molecule.

g) An anion has a positive charge.

h) The triple bond in an alkyne is between two sp hybridized carbons.

i) Saturated compounds have the maximum number of bonds to hydrogen.

j) The conjugate base of Nitric Acid ($HNO_3$) is the $NO_3^-$ anion.

2) Define the following terms (3pts):

   * Syn Addition

   * Substitution reaction

   * Racemic mixture
3) Name the classes of compound (functional groups) that the following molecules belong to (e.g. alkane, amide, etc.) (5pts)

4) Circle the above functional group that will likely be the most acidic. (1pt)

5) (4pts) For the below molecule:

How many Hydrogens are there?
How many π bonds?
How many sp³ hybridized Carbons?
What is the hybridization of the Oxygen?
6) Write a mechanism (i.e. curly arrows) for this electrophilic addition. (6pts)

\[
\begin{align*}
\text{H}_3\text{C} & \text{=C} \text{=C-H}_3 & \text{Br} & \text{Br} & \rightarrow \\
\text{Br} & \text{C} = \text{C} & \text{=C-H}_3 & \text{H}_3\text{C} & \text{Br}
\end{align*}
\]

7) Name the following molecules in IUPAC form. (12pts)

(a) \[
\begin{align*}
\text{CH}_3
\end{align*}
\]

(b) \[
\begin{align*}
\text{Ph}
\end{align*}
\]

(c) \[
\begin{align*}
\text{CH}_3
\end{align*}
\]
8) (i) Draw in the curly arrows for this acid catalyzed elimination. (6pts)

\[ \text{OH} \xrightarrow{\text{HSO}_3^-} \text{H}_3\text{O}^+ \]

\[ \text{CH}_2=\text{CH}_2 \xrightarrow{\text{H}_2\text{O}} \]

(ii) Provide the specific name of the above reaction mechanism type – it should involve at least one letter, and a number. (1pt)

9) Assign R or S to each chiral center in these molecules. (6pts)

(a) \[ \text{CH}_3 \]
(b) \[ \text{H}_3\text{C} \]
(c) \[ \text{CO}_2\text{H} \]
10) (6 pts) For the below energy level diagram...

![Diagram of reaction coordinate with labels: Energy, Reaction Coordinate, Starting Materials, Products]

a) is this reaction *exothermic* or *endothermic*?

b) Will the Equilibrium constant ($K_{eq}$) be *greater* or *less* than 1.00?

c) how many transition states are there?

d) how many steps is this multistep reaction?

e) which step is the rate determining step?

f) which is the fastest step?
11) Give the reagents for the following alkene reactions. (8pts)

12) Give the products for the following alcohol transformations. (8pts)
13) Give the reagents (for a & c), and the products (for b & d). (8pts)

a) $\text{H}_3\text{C} \equiv \text{C} \equiv \text{C} - \text{CH}_3 \quad \rightarrow \quad \text{cis-but-2-ene}$

b) $\text{H}_3\text{C} \equiv \text{C} \equiv \text{C} - \text{H}$
   
i) $\text{Si}_2\text{BH}$
   
   ii) $\text{H}_2\text{O}_2$, $\text{NaOH}$

c) $\text{H}_3\text{C} \equiv \text{C} \equiv \text{C} - \text{CH}_3 \quad \rightarrow \quad \text{CH}_3\text{CH} = \text{CH}_2$

d) $\text{H}_3\text{C} \equiv \text{C} \equiv \text{C} - \text{H}$
   
i) $\text{NaNH}_2$
   
   ii) $\text{H}_2\text{O}$
   
   iii) $\text{PhCH}_2\text{-Br}$

14) (2+2+1+1=6pts) Draw two molecules that are structural isomers.

Draw two molecules that are stereoisomers.

What is meant by a diastereomer?

What are tautomers?
15) Write the mechanism (i.e. curly arrows) for the following $S_N2$ transformation: (6pts)

\[ \text{R-OH} + \text{H-Br} \rightarrow \text{R-Br} + \text{H}_2\text{O} \]

16) Circle the lowest energy member of each threesome. (4pts)

(a) \[ \text{H} \text{CH}_3 \quad \text{H} \text{CH}_3 \quad \text{H} \text{CH}_3 \]

(b) \[ \text{Br} \text{F} \text{N(CH}_3)_2 \quad \text{Br} \text{F} \text{N(CH}_3)_2 \quad \text{F} \text{N(CH}_3)_2 \]

(c) \[ \text{F} \text{H} \text{H} \quad \text{F} \text{H} \text{H} \quad \text{F} \text{F} \text{H} \]

(d) \[ \text{HO-CH}_2\text{Cl} \quad \text{HO-CH}_2\text{Cl} \quad \text{HO-CH}_2\text{Cl} \]
***BONUS POINTS (up to THREE)***

Provide both the first and last names of three people who took Organic 1 lecture this semester (you cannot include yourself, but you can include me).
Name: WATSON D. HORIZON

(1 a-j) are TRUE/FALSE (10pts)

a) Chiral molecules have non-superimposable mirror images. \[ T \]
b) \( S_N l \) and \( E_1 \) reactions both proceed through carbocation intermediates. \[ T \]
c) A triple bond has two \( \pi \) bonds and one \( \sigma \) bond. \[ T \]
d) Cyclopropane has more ring strain than cyclobutane. \[ T \]
e) Cahn, Ingold and Prelog created the rules for assigning R or S to a chiral center. \[ T \]
f) Cyclohexanol is a chiral molecule. \[ False \]
g) An anion has a positive charge. \[ False \]
h) The triple bond in an alkyne is between two sp hybridized carbons. \[ T \]
i) Saturated compounds have the maximum number of bonds to hydrogen. \[ T \]
j) The conjugate base of Nitric Acid (HNO\( _3 \)) is the NO\( _3^- \) anion. \[ T \]

2) Define the following terms (3pts):

**Syn Addition** The addition of two atoms or groups to the same side or face of a molecule.

**Substitution reaction** A reaction where one atom or group is substituted for another atom or group.

**Racemic mixture** An equal amount of both enantiomers of a chiral species.
3) Name the classes of compound (functional groups) that the following molecules belong to (e.g. alkane, amide, etc.) (5pts)

- Aldehyde
- Alcohol
- Thiol
- Ether
- Carboxylic Acid

4) Circle the above functional group that will likely be the most acidic. (1pt)

5) (4pts) For the below molecule:

- How many Hydrogens are there? 14
- How many $\pi$ bonds? 1
- How many $sp^3$ hybridized Carbons? 8
- What is the hybridization of the Oxygen? $sp^3$
6) Write a mechanism (i.e. curly arrows) for this electrophilic addition. (6pts)

\[
\begin{align*}
\text{H}_3\text{C}=\text{C}=&\text{C}-\text{CH}_3 & \text{Br}-\text{Br} \\
& \text{Br} & \text{Br}
\end{align*}
\]

7) Name the following molecules in IUPAC form. (12pts)

(a) 4-Methylpent-1-yne

(b) 4-Cyclopropyloctane

(c) 2-Ethylcyclohexa-1,3-diene
8) (i) Draw in the curly arrows for this acid catalyzed elimination. (6pts)

\[ \text{OH} \quad \xrightarrow{\text{HOSO}_4^{-}} \quad \text{H}_3\text{O}^+ \]

\[ \xrightarrow{\text{HOSO}_4^{-}} \quad \text{SO}_4^{2-} \]

\[ \text{H}_3\text{O}^+ \]

(ii) Provide the specific name of the above reaction mechanism type – it should involve at least one letter, and a number. (1pt)

E1

9) Assign R or S to each chiral center in these molecules. (6pts)

(a) \[ \text{CH}_3 \quad \text{F} \quad \text{Cl} \quad \text{NH}_2 \]

(b) \[ \text{H}_3\text{C} \quad \text{H} \quad \text{H} \quad \text{F} \]

(c) \[ \text{CO}_2\text{H} \quad \text{H} \quad \text{H} \quad \text{Br} \quad \text{CF}_2\text{H} \]

Assignments:

(a) $R$

(b) $R$ (excluding the one in the ring)

(c) $S$
10) (6 pts) For the below energy level diagram...

![Energy Level Diagram](image)

a) Is this reaction **exothermic** or **endothermic**?

b) Will the Equilibrium constant ($K_{eq}$) be **greater** or **less** than 1.00?

c) How many transition states are there? **Two**

d) How many steps is this multistep reaction? **Two**

e) Which step is the rate determining step? **2nd step**

f) Which is the fastest step? **1st step**
11) Give the **reagents** for the following alkene reactions. (8pts)

![Chemical reaction diagram](image)

12) Give the products for the following alcohol transformations. (8pts)

![Chemical reaction diagram](image)
13) Give the reagents (for a & c), and the products (for b & d). (8pts)

a) \( \text{H}_3\text{C}-\text{C}≡\text{C}-\text{CH}_3 \) \( \xrightarrow{\text{H}_2, \text{Lindlar's Catalyst}} \) \( \text{cis-but-2-ene} \)

\( \) \( \text{(Pd, BaO}, \text{Quinoline)} \)

b) \( \text{H}_3\text{C}-\text{C}≡\text{C}-\text{H} \)
   i) \( \text{Si}_2\text{BH} \)
   ii) \( \text{H}_2\text{O}_2, \text{NaOH} \)

\( \xrightarrow{\text{[\text{CH}_3\text{CH}_2\text{C}≡\text{C}]}} \) \( \text{CH}_3\text{CH}_2\text{C}≡\text{C}-\text{H} \)

c) \( \text{H}_3\text{C}-\text{C}≡\text{C}-\text{CH}_3 \) \( \xrightarrow{\text{Na}, \text{NH}_3} \)

\( \text{cis-2-propene} \)

d) \( \text{H}_3\text{C}-\text{C}≡\text{C}-\text{H} \)
   i) \( \text{NaNH}_2 \)
   ii) \( \text{H} \)
   iii) \( \text{PhCH}_2\text{-Br} \)

\( \xrightarrow{\text{CH}_3-\text{C}≡\text{C}^\circ} \) \( \xrightarrow{\text{CH}_3-\text{C}≡\text{C}^\circ} \)

14) (2+2+1+1=6pts) Draw two molecules that are \textit{structural isomers}.

\[ \text{E.g.} \quad \text{ } & \quad \text{ } \quad \text{or} \quad \text{ } & \quad \text{ } \]

Draw two molecules that are \textit{stereoisomers}.

\[ \text{E.g.} \quad \text{ } & \quad \text{ } \quad \text{or} \quad \text{ } & \quad \text{ } \]

What is meant by a \textit{diastereomer}?

\textit{A stereoisomer which is not an enantiomer.}

What are \textit{tautomers}?

\textit{Structural isomers that are in equilibrium with each other.}
15) Write the mechanism (i.e. curly arrows) for the following $S_N2$ transformation: (6pts)

$$\text{R-OH} + \text{H-Br} \rightarrow \text{R-Br} + \text{H}_2\text{O}$$

16) Circle the lowest energy member of each threesome. (4pts)

(a) $\text{H-O-CH}_3$ $\text{O-CH}_3$ $\text{H-CH}_3$

(b) $\text{Br-N(CH}_3)_2$ $\text{N(CH}_3)_2$ $\text{Br-N(CH}_3)_2$

(c) $\text{F-H}$ $\text{H}$ $\text{F-H}$

(d) $\text{HO-CH}_2\text{Cl}$ $\text{HO-CH}_2\text{Cl}$ $\text{HO-CH}_2\text{Cl}$