Fall 00 Organic I Final Exam

Name

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1) (5pts total) Give one definition of an Acid

b) Give one definition of a base

c) Without using profanity, what is “Organic Chemistry”?

2) Briefly explain what is meant the following terms:(16pts total)
Electronegativity

Chiral Molecule

Optically Active Mixture

Rate Determining Step

Syn Addition

Markovnikov Addition

Mechanism

π Bond
3) Name the classes of compound that the following molecules belong to (E.g. alkane, amide, etc). (15pts)

\[
\begin{align*}
R\equiv R & \quad \text{O} \quad R\equiv R \\
R-O-O-R & \quad R\equiv R & \quad R\equiv O-H \\
\text{O} & \quad \text{O} & \quad \text{O} \\
\text{R} & \quad \text{H} & \quad \text{R} & \quad \text{O-H} & \quad \text{R} & \quad \text{O-R} \\
R-S-H & \quad \text{O} & \quad \text{R} & \quad \text{R}
\end{align*}
\]

4) Draw Lewis structures (sticks for bonds, and dots for lone pairs) for the below two molecules. (10pts)

\[
\begin{align*}
\text{O} & \quad \text{OH} \\
\text{Cl} & \quad \text{C} \quad \text{C} \quad \text{C} \\
\end{align*}
\]

5) For the previous two molecules, label the hybridization of all the carbons and oxygens. (5pts)
6) Classify each of the following reactions as an Elimination, Addition or Substitution. (5pts)

(a) \[ \ce{H3C=H} \rightarrow \ce{H3C=C=CH3} \]

(b) \[ \ce{H3C=CH=CH3} \rightarrow \ce{H3C-CH=CH2} \]

(c) \[ \ce{Ph=H} \rightarrow \ce{Ph-Br} \]

(d) \[ \ce{\bigcirc} \rightarrow \ce{\bigcirc-OH} \]

(e) \[ \ce{H3C=H} \rightarrow \ce{H2=C=CH3} \]

7) Explain why the tosylate group is such a good leaving group. (9pts)

[Diagram of tosylate anion]
8) On the below energy level diagram, label (a) the axes (b) the reactants and products (c) any transitions states (d) $\Delta H^\circ$ for the overall reaction (e) the rate determining step (f) is this reaction exothermic or endothermic? (9pts)

![Energy Level Diagram](image)

9) By considering the hybridization of the oxygen atom, predict the shapes and bond angles of $\text{H}_2\text{O}$ and $\text{H}_3\text{O}^+$. (10pts)
10) Name the following molecules in IUPAC form. (16pts)

(a) 

(b) 

(c) 

(d) 

(e)
11) Asterix (star, *) the chiral atoms in these molecules, and assign R or S to each chiral center. (13pts)

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

(b) \[\text{Br} \quad \text{H} \quad \text{CF}_3\]

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

(d) \[\text{Cl} \quad \text{H} \quad \text{CF}_2\text{H}\]

12) Which of the above molecules are achiral, and in a sentence explain what makes them achiral. (3pts)
13) Circle the more stable member of each pair, and in a sentence explain your choice. (10pts)

(a) HO$^-$  H$_2$N$^-$

(b) CH$_3$CH$_2$O$^-$  CFH$_2$CH$_2$O$^-$

(c)

(d)

(e)

14) The most stable conformation for a cyclohexane ring bearing an ethyl group is a “chair conformation with the ethyl group equatorial”.

(i) Explain what the chair conformation is (4pts)

(ii) Explain what ‘equatorial’ is (4pts)
(iii) Explain why it is energetically preferred to put the substituent equatorial. (6pts)

15) Provide a mechanistic explanation for the observed mixture of products in the following E1 reaction. (10pts)
16) Give the products of 5 of the 6 following reactions. (15pts)

(a) \[
\text{CH}_3\text{CH}_2=\text{CH}_3 \xrightarrow{\text{excess I}_2} \]

(b) \[
\text{I} \xrightarrow{1) \text{Mg, Ether}} \xrightarrow{2) \text{H}_2\text{C}=\text{O}} \xrightarrow{3) \text{H}_3\text{O}^+}
\]

(c) \[
\text{Cyclic ring} \xrightarrow{\text{OsO}_4, \text{H}_2\text{O}_2}
\]

(d) \[
\text{H}_3\text{C} \xrightarrow{1) \text{BH}_3\cdot\text{THF}} \xrightarrow{2) \text{H}_2\text{O}_2, \text{NaOH}}
\]

(e) \[
\text{Cyclic ring} \xrightarrow{\text{Br}_2}
\]

(f) \[
\text{Ph} \xrightarrow{1) \text{Na, NH}_3}
\]

16b) Write the mechanism for one of the preceding reactions. (10pts)
17) Give reagents to perform 5 of the 6 following transformations. (15pts)

(a) \[
\begin{array}{c}
\text{Cyclohexanol} \\
\end{array} \rightarrow \begin{array}{c}
\text{Cyclohexanone} \\
\end{array}
\]

(b) \[
\begin{array}{c}
\text{Cyclohexanol} \\
\end{array} \rightarrow \begin{array}{c}
\text{Cyclohexene} \\
\end{array}
\]

(c) \[
\begin{array}{c}
\text{Propyne} \\
\end{array} \rightarrow \begin{array}{c}
\text{Acetone} \\
\end{array}
\]

(d) \[
\begin{array}{c}
\text{Cyclohexanol} \\
\end{array} \rightarrow \begin{array}{c}
\text{Cyclohexyne} \\
\end{array}
\]

(e) \[
\begin{array}{c}
\text{Cyclopentene} \\
\end{array} \rightarrow \begin{array}{c}
\text{Bromocyclopentylmethanol} \\
\end{array}
\]

(f) \[
\begin{array}{c}
\text{Propyne} \\
\end{array} \rightarrow \begin{array}{c}
\text{Acetaldehyde} \\
\end{array}
\]

17b) Write the mechanism for one of the preceding reactions. (10pts)
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1) (5pts total) Give one definition of an Acid
   \( \text{H}^+ \) donor ⟷ forms \( \text{H}_2\text{O}^+ \) in water ⟷ \( \text{e}^- \) acceptor

b) Give one definition of a base
   \( \text{H}^+ \) acceptor ⟷ forms \( \text{OH}^- \) in water ⟷ \( \text{e}^- \) donor

c) Without using profanity, what is "Organic Chemistry"?
   Awesome and cool. (And the study of carbon containing compounds.)

2) Briefly explain what is meant the following terms: (16pts total)
   Electronegativity
   The ability to bear \(-\)ve charge effectively

   Chiral Molecule
   A molecule with a non-superimposable mirror image

   Optically Active Mixture
   A mixture containing unequal amounts of two enantiomers

   Rate Determining Step
   Slowest step in a multistep process.

   Syn Addition
   Addition of two species to the same face of what was a multiple bond.

   Markovnikov Addition
   Add of \( \text{H}-\text{X} \) to a multiple bond where \( \text{X} \) goes onto the most highly substituted end.

   Mechanism
   Step by step movement of electrons describing a reaction.

   \( \pi \) Bond
   A bond formed by sideways overlap of \( p \) orbitals.
3) Name the classes of compound that the following molecules belong to (E.g. alkane, amide, etc). (15pts)

- Ethyne
- Peroxide
- Aldehyde
- Carboxylic Acid
- Thiol
- Ketone

4) Draw Lewis structures (sticks for bonds, and dots for lone pairs) for the below two molecules. (10pts)

5) For the previous two molecules, label the hybridization of all the carbons and oxygens. (5pts)

- Red = $sp^3$
- Black = $sp^2$
- Green = $sp^3$
6) Classify each of the following reactions as an Elimination, Addition or Substitution. (5pts)

(a) \[
\text{H}_3\text{C} = \text{C} \quad \xrightarrow{} \quad \text{H}_2\text{C} = \text{C} = \text{C} = \text{CH}_3
\]

(b) \[
\text{H}_3\text{C} = \text{C} = \text{CH}_3 \quad \xrightarrow{} \quad \text{H}_3\text{C} - \text{C} = \text{C} = \text{CH}_3
\]

(c) \[
\text{Ph} = \text{C} = \text{C} \quad \xrightarrow{} \quad \text{Ph} = \text{C} = \text{C} - \text{C} = \text{C} = \text{Ph}
\]

(d) \[
\text{H}_2\text{C} - \text{C} = \text{C} = \text{CH}_3 \quad \xrightarrow{} \quad \text{H}_2\text{C} - \text{C} = \text{C} = \text{CH}_3
\]

(e) \[
\text{H}_3\text{C} = \text{C} \quad \xrightarrow{} \quad \text{H}_2\text{C} = \text{C} = \text{CH}_3
\]

7) Explain why the tosylate group is such a good leaving group. (9pts)

The anion is resonance stabilized over 3 oxygen atoms & the anion is very stable.
8) On the below energy level diagram, label (a) the axes (b) the reactants and products (c) any transition states (d) $\Delta H^\circ$ for the overall reaction (e) the rate determining step (f) is this reaction exothermic or endothermic? (9pts)

![Energy Level Diagram]

9) By considering the hybridization of the oxygen atom, predict the shapes and bond angles of $H_2O$ and $H_3O^+$. (10pts)

$$H\cdot\overset{\text{o}}{O}\cdot\overset{\text{H}}{H} = 2\sigma\text{ bonds}$$

2 lone pairs

$\Rightarrow$ $sp^3$ hybridization of Oxygen

$\Rightarrow$ bond angles of 104.5°

Molecule Shape is Bent.

(Bond angles slightly less than 104.5° since lone pairs repel more than bond pairs.)

$$H\cdot\overset{\text{o}}{O}\cdot\overset{\text{H}}{H} = 3\sigma\text{ bonds}$$

1 lone pair

$\Rightarrow$ $sp^3$ hybridization of O

$\Rightarrow$ bond angles of 109.5°

Molecule is Trigonal Pyramidal

(with bond angles less than 109.5°)
10) Name the following molecules in IUPAC form. (16pts)

(a) \[ \text{2-Chloro pentane} \]

(b) \[ \text{2 Methyl-1,3-butadiene} \]

(c) \[ \text{trans 1-bromo 3-chlorocyclobutane (anti)} \]

(d) \[ \text{4 Fluoro Hex-1-ene} \]

(e) \[ \text{4 Bromo Phenol} \]
11) Asterix (star, *) the chiral atoms in these molecules, and assign R or S to each chiral center. (13pts)

(a) 

(b) No chiral atoms.

(c) 

(d) 

12) Which of the above molecules are achiral, and in a sentence explain what makes them achiral. (3pts)

(a) No chiral elements

(d) Meso compound, mirror plane of symmetry.
13) Circle the more stable member of each pair, and in a sentence explain your choice. (10pts)

(a) \( \text{HO}^- \) \( \text{H}_2\text{N}^- \)  
- O more electronegative

(b) \( \text{CH}_3\text{CH}_2\text{O}^- \) \( \text{CFH}_2\text{CH}_2\text{O}^- \)  
- Electron withdrawing F helps stabilize the charge

(c) \( \text{+} \) \( \text{+} \)  
- Secondary cation more stable than primary due to more alkyl groups.

(d) \( \text{--} \) \( \text{=CH}_2 \)  
- Resonance stabilized anion.

(e) \( \text{--} \) \( \text{+} \)  
- Resonance stabilized cation.

14) The most stable conformation for a cyclohexane ring bearing an ethyl group is a “chair conformation with the ethyl group equatorial”.

(i) Explain what the chair conformation is (4pts)

![Chair conformation diagram]

The six carbons in the ring resemble a chair.

(ii) Explain what ‘equatorial’ is (4pts)

![Equatorial and axial diagram]

The equatorial positions point at subways from the molecule.
(iii) Explain why it is energetically preferred to put the substituent equatorial. (6pts)

This minimizes the e/e repulsion between the substituent & the rest of the molecule.

The axial position suffers from 1,3 dihedral interactions.

15) Provide a mechanistic explanation for the observed mixture of products in the following E1 reaction. (10pts)
16) Give the products of 5 of the 6 following reactions. (15pts)

(a) \( \text{CH}_3\text{CH}_2 = \text{C} = \text{CH}_3 \quad \text{excess } \text{I}_2 \rightarrow \text{CH}_3\text{CH}_2 - \text{C} = \text{C} - \text{CH}_3 \quad \text{I} \quad \text{I} \)

(b) \( \begin{array}{c}
\text{I} \\
1) \text{Mg, Ether} \\
2) \text{H}_2\text{C} = \text{O} \\
3) \text{H}_3\text{O}^+ \\
\end{array} \)

(c) \( \text{OsO}_4, \text{H}_2\text{O}_2 \rightarrow \text{OH} \quad \text{OH} \)

(d) \( \begin{array}{c}
\text{H}_3\text{C} - \text{C} - \text{H} \\
1) \text{BH}_3, \text{THF} \\
2) \text{H}_2\text{O}_2, \text{NaOH} \\
\end{array} \)

(e) \( \text{Br}_2 \rightarrow \text{Br} \quad \text{Br} \)

(f) \( \text{Ph} - = - \text{Ph} \quad 1) \text{Na, NH}_3 \)

16b) Write the mechanism for one of the preceding reactions. (10pts)
17) Give reagents to perform 5 of the 6 following transformations. (15pts)

(a) \( \text{H}_2\text{CO}_2\text{H} \rightarrow \text{HO-} \rightarrow \text{CO} \)

(b) \( \text{OH} \)

(c) \( \text{H}_3\text{C} = \text{H} \)

(d) \( \text{OH} \)

(e) \( \text{Br}_2, \text{CH}_3\text{OH} \)

(f) \( \text{H}_3\text{C} = \text{H} \)

17b) Write the mechanism for one of the preceding reactions. (10pts)