Name
If you do not want your graded exam placed in the box outside my office, then please check here □

Answer all the questions

(1-10) Are True or False (20pts)

1) Organic Chemistry is the study of Carbon containing compounds.

2) A π covalent bond must be polar.

3) The Cahn-Ingold and Prelog convention describes rules for assigning (+) and (-) to chiral centers.

4) The Hammond Postulate states that entropy is inverted at a neutral chiral cation.

5) A typical C=C bond length is around 1.3 x 10^-5 m.

6) For X chiral centers, there are X^2 maximum possible stereoisomers.

7) The change in Gibbs free energy can be expressed as ΔG = ΔH — TΔS.

8) HO^- is a stronger base than H_2O.

9) Increasing the reaction temperature encourages elimination reactions relative to substitution reactions.

10) Organometallic reagents have a metal connected to a carbon.

Define the following terms: (8pts)

11) Nucleophile

12) Lewis Acid

13) Meso compound

14) Kinetics.
15) Name the classes of compound that the following molecules belong to (E.g. alkane, amide, etc.). (20pts)

- $\text{R} - \equiv - \text{R}$
- $\text{R} - \equiv - \text{R}$
- $\text{R} - \equiv - \text{R}$
- $\text{R} - \equiv - \text{R}$

16) (18pts) For the following molecule, calculate the number of...

- a) carbon atoms
- b) hydrogen atoms
- c) $\pi$ bonds
- d) $sp^2$ hybridized carbons
- e) $sp$ hybridized atoms
- f) halogens
- g) lone pairs (non bonding pairs) of electrons
- h) the C-O-C bond angle
- i) carbons in the ring.
17) For each of the following reactions state whether the regiochemistry is *Markovnikov, Anti-Markovnikov* or *Neither*. (12pts)

18) In the lowest energy conformation of *trans*-1,2-dimethylocyclohexane, how many axial positions are occupied by Hydrogen atoms? (6pts)
19) (i) Write a mechanism (i.e. curly arrows) for this E1 elimination. (8pts)

\[
\begin{array}{c}
\text{Br} \\
\text{K^+OCH}_3, \text{CH}_3\text{OH} \\
\text{\text{\rightarrow}} \end{array}
\]

(ii) Is the above product *Hoffman* or *Saytzeff*? (3pts)

(iii) There is also another (minor) alkene product that is formed from this elimination, draw this product. (3pts)

20) Draw the following molecules: (10pts)

3-*Fluoro-1-pentyne*  \hspace{2cm} \textit{cis-2-Methylcyclobutanol}
21) Explain (including curly arrows) why in this electrophilic addition reaction, none of product A is generated, and product B is formed exclusively. (10pts)

Product A

Product B

22) Name the following compounds in IUPAC format. (8pts)

(a) OH

(b) CH₃CH₂CH₂H
    CH₃CH₂CH₂H
    H
    CH₂CH₂CH₂Br
23) Assign R or S to each chiral center in these molecules. (12pts)

(a)

(b)

(c)

(d)

24) What is the name of this type of Projection? (2pts)

(b) What is meant by the term diastereomer? (2pts)

c) Draw two molecules that are structural isomers. (5pts)
25) Circle the most stable member of each threesome. (12pts)
26) Give the reagents or products for 6 of the 8 following reactions. (18pts)

(a) \[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}=\text{CH}-\text{CH}_3 & \quad \xrightarrow{} \quad \text{CH}_3\text{CH}_2\text{-CH}_3 \\
\end{align*}
\]

(b) \[
\begin{align*}
\text{H}_3\text{C}-\text{C}≡\text{C}-\text{H} & \quad \xrightarrow{\text{NaNH}_2} \\
\end{align*}
\]

(c) \[
\begin{align*}
\text{H}_2\text{C} & \quad \xrightarrow{} \quad \text{H}_2\text{C} \cdot \text{C} \cdot \text{H}_2 \\
\end{align*}
\]

(d) \[
\begin{align*}
\text{H}_2\text{C} & \quad \xrightarrow{} \quad \text{H}_2\text{C} \cdot \text{C} \cdot \text{H}_2 \\
\end{align*}
\]

(e) \[
\begin{align*}
\text{H}_3\text{C}-\text{C}≡\text{C}-\text{H} & \quad \xrightarrow{\text{Excess HCl}} \\
\end{align*}
\]

(f) \[
\begin{align*}
\text{H}_3\text{C}-\text{C}≡\text{C}-\text{H} & \quad \xrightarrow{\text{HgSO}_4, \text{H}_2\text{SO}_4, \text{H}_2\text{O}} \\
\end{align*}
\]

(g) \[
\begin{align*}
\text{H}_3\text{C}-\text{C}≡\text{C}-\text{CH}_3 & \quad \xrightarrow{\text{H}_2, \text{Lindlar's Catalyst}} \\
\end{align*}
\]

(h) \[
\begin{align*}
\text{H}_2\text{C} & \quad \xrightarrow{} \quad \text{H}_2\text{C} \cdot \text{C} \cdot \text{H}_2 \\
\end{align*}
\]
27) Give the products in 5 of the 6 following transformations. (15pts)

28) Draw curly arrows to show the mechanism of the following S_N1 reaction. (8pts)
Bonus question (up to 6 points).

What were the three joke names used for the perfect answers to this year’s three exams?
(1-10) Are True or False (20pts)

1) Organic Chemistry is the study of Carbon containing compounds. \( \text{True} \)

2) A \( \pi \) covalent bond must be polar. \( \text{False} \)

3) The Cahn-Ingold and Prelog convention describes rules for assigning (+) and (-) to chiral centers. \( \text{False} \)

4) The Hammond Postulate states that entropy is inverted at a neutral chiral cation. \( \text{False} \)

5) A typical C=C bond length is around \( 1.3 \times 10^{-5} \) m. \( \text{False} \)

6) For \( X \) chiral centers, there are \( X^2 \) maximum possible stereoisomers. \( \text{False} \)

7) The change in Gibbs free energy can be expressed as \( \Delta G = \Delta H - T \Delta S \). \( \text{True} \)

8) \( \text{HO}^- \) is a stronger base than \( \text{H}_2\text{O} \). \( \text{True} \)

9) Increasing the reaction temperature encourages elimination reactions relative to substitution reactions. \( \text{True} \)

10) Organometallic reagents have a metal connected to a carbon. \( \text{True} \)

Define the following terms (8pts)

11) \textbf{Nucleophile} \hspace{1cm} \text{A two electron donor}

12) \textbf{Lewis Acid} \hspace{1cm} \text{A two electron acceptor}

13) \textbf{Meso compound} \hspace{1cm} \text{An achiral compound with chiral centers}

14) \textbf{Kinetics} \hspace{1cm} \text{The study of reaction rates}
15) Name the classes of compound that the following molecules belong to (E.g. alkane, amide, etc). (20pts)

- Ester
- Phosphate Ester
- Carboxylic Acid
- Alkyne
- Alkyl peroxide
- Ether
- Alcohol
- Ketone
- Acid Chloride
- Peroxyacid

16) (18pts) For the following molecule, calculate the number of ...

a) carbon atoms 9
b) hydrogen atoms 11
c) π bonds 3
d) sp² hybridized carbons 5
e) sp hybridized atoms 0
f) halogens 1
g) lone pairs (non bonding pairs) of electrons 7
h) the C-O-C bond angle $\text{sp}^3 = 109.5^\circ$
i) carbons in the ring 5
17) For each of the following reactions state whether the regiochemistry is Markovnikov, Anti-Markovnikov or Neither. (12pts)

18) In the lowest energy conformation of trans-1,2-dimethylecyclohexane, how many axial positions are occupied by Hydrogen atoms? (6pts)
19) (i) Write a mechanism (i.e. curly arrows) for this E1 elimination. (8pts)

\[
\begin{align*}
\text{Br} & \quad \text{K}^+\text{OCH}_3, \text{CH}_3\text{OH} \\
& \quad \downarrow \\
\end{align*}
\]

ii) Is the above product Hoffman or Saytzeff? (3pts)

iii) There is also another (minor) alkene product that is formed from this elimination, draw this product. (3pts)

20) Draw the following molecules: (10pts)

- 3-Fluoro-1-pentyne
- cis-2-Methylcyclobutanol
21) Explain (including curly arrows) why in this electrophilic addition reaction, none of product A is generated, and product B is formed exclusively. (10pts)

Product A

Product B

Primary carbocation
less stable
not formed

(Allylic groups stabilize carbocation)

Tertiary carbocation
more stable, preferentially formed, giving the Malononitrile product.

22) Name the following compounds in IUPAC format. (8pts)

(a) \chem{\begin{tikzpicture}
  \node (a) at (0,0) {OH};
  \node (1) at (-1,0) {1};
  \node (2) at (0,0) {2};
  \node (3) at (1,0) {3};
  \draw (a) -- (1);
  \draw (a) -- (2);
  \draw (a) -- (3);
\end{tikzpicture}}

1-propanol

(b) \chem{\begin{tikzpicture}
  \node (a) at (0,0) {H};
  \node (1) at (-1,0) {1};
  \node (2) at (0,0) {2};
  \node (3) at (-2,0) {3};
  \node (4) at (0,0) {4};
  \node (5) at (1,0) {5};
  \node (6) at (2,0) {6};
  \node (7) at (3,0) {7};
  \node (8) at (4,0) {8};
  \node (9) at (5,0) {9};
  \draw (a) -- (1);
  \draw (a) -- (2);
  \draw (a) -- (3);
  \draw (3) -- (4);
  \draw (4) -- (5);
  \draw (5) -- (6);
  \draw (6) -- (7);
  \draw (7) -- (8);
  \draw (8) -- (9);
\end{tikzpicture}}

(E)-1-bromo-4-octene
23) Assign R or S to each chiral center in these molecules. (12pts)

(a) 
\[
\begin{array}{c}
\text{F} \\
\text{Cl} \\
\text{H}_3\text{C} \\
\text{NH}_2 \\
\end{array}
\]

(b) 
\[
\begin{array}{c}
\text{F} \\
\text{H} \\
\text{H} \\
\text{H}_3\text{C} \\
\text{O} \\
\end{array}
\]

(c) 
\[
\begin{array}{c}
\text{H} \\
\text{Cl} \\
\text{H}_3\text{C} \\
\text{Cl} \\
\end{array}
\]

(d) 
\[
\begin{array}{c}
\text{CO}_2\text{H} \\
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{CF}_2\text{H} \\
\end{array}
\]

24) What is the name of this type of Projection? (2pts)

(b) What is meant by the term *diastereomer*? (2pts)

\text{A stereoisomer which is not a enantiomer}

(c) Draw two molecules that are *structural isomers*. (5pts)

\[\text{C}_4\text{H}_8\] 
\[\text{C}_2\text{H}_5\text{OH}\]
25) Circle the most stable member of each threesome. (12pts)
26) Give the reagents or products for 6 of the 8 following reactions. (18pts)

(a) \[ \text{CH}_3\text{CH}_2\text{CH} = \text{CH}_3 \xrightarrow{\text{BH}_3} \text{CH}_3\text{CH}_2\text{CH} - \text{CH}_3 \xrightarrow{\text{H}_2\text{O}_2, \text{NaOH}} \text{CH}_3\text{CH}_2\text{CH} - \text{CH}_3 \]

(b) \[ \text{H}_3\text{C} - \text{C}=\text{C}-\text{H} \xrightarrow{\text{NaNH}_2} \text{H}_3\text{C} - \text{C}=\text{C}:\text{Na}^+ \]

(c) \[ \text{C}_5\text{H}_8 \xrightarrow{\text{OsO}_4, \text{H}_2\text{O}_2} \text{C}_5\text{H}_{10} \]

(d) \[ \text{C}_5\text{H}_8 \xrightarrow{\text{Hg(CA}_3)_2, \text{H}_2\text{O}} \text{C}_5\text{H}_{10} \text{ and } \text{C}_5\text{H}_{10} \text{OH} \]

(e) \[ \text{H}_3\text{C} - \text{C}=\text{C}-\text{H} \xrightarrow{\text{Excess HCl}} \text{C}_4\text{H}_9\text{Cl}_2 \]

(f) \[ \text{H}_3\text{C} - \text{C}=\text{C}-\text{H} \xrightarrow{\text{HgSO}_4, \text{H}_2\text{SO}_4, \text{H}_2\text{O}} \text{CH}_3\text{CH} = \text{CH}_2 \]

(g) \[ \text{H}_3\text{C} - \text{C}=\text{C}-\text{CH}_3 \xrightarrow{\text{H}_2, \text{Lindlar's Catalyst}} \]

(h) \[ \text{C}_5\text{H}_8 \xrightarrow{\text{C}-\text{O}-\text{O}} \text{C}_5\text{H}_8 \text{O} \]
27) Give the products in 5 of the 6 following transformations. (15pts)

28) Draw curly arrows to show the mechanism of the following $S_N1$ reaction. (8pts)
Bonus question (up to 6 points).

What were the three joke names used for the perfect answers to this year’s three exams?

JUAN LOHAN-PIERRE (one lone pair)
RAY KUPLEAVES (make up leaves)
PSU MDE Lester (P.S.U. molester)