1-10 are True / False (10pts)

1) Enantiomers are non-superimposable mirror images.

2) Single bonds are typically shorter and stronger than double bonds.

3) $\text{S}_2$ reactions generate 100% inversion of stereochemistry because the nucleophile must attack from directly behind the Carbon – Leaving Group bond.

4) (R) or (S) stereocenters are assigned according to rules of the Cahn-Ingold-Prelog convention.

5) An elimination is a reaction where two atoms or groups are removed to produce a new $\pi$ bond.

6) Hex-1-ene and Cyclohexane are stereoisomers.

7) A diastereomer is a stereoisomer which is not an enantiomer.

8) Saytzeff's rule states that the major product from an elimination will be the more highly alkyl substituted $\pi$ bond.

9) A Leaving Group must be a good Proton donor.

10) Hydrogen Bromide and Peroxides is the reagent set used to add H and Cl, with Anti-Markovnikov regiochemistry, with Syn stereochemistry to alkenes.
11) (5pts) Below is Ibuprofen, a nonsteroidal anti-inflammatory drug (NSAID) that is used for treating pain, fever, and inflammation. It is available under trade names, including Advil and Motrin. It is the #1 selling OTC pain reliever in the USA.

\[
\text{\includegraphics[width=0.3\textwidth]{ibuprofen.png}}
\]

Determine:

a) The number of Carbons.

b) The number of Hydrogens.

c) The number of \(\pi\) bonds.

d) The number of chiral centers.

e) Based on your answer to (d) – how many different stereoisomers fit the above (imprecise) structural representation?

12) (3+4=7pts) Name these two compounds in IUPAC form.

\[
\text{\includegraphics[width=0.3\textwidth]{compound1.png}} \quad \text{\includegraphics[width=0.3\textwidth]{compound2.png}}
\]
13) (4pts) Draw in the curly arrows for this acid catalyzed elimination.

14) (1pt) Circle the most stable cation in this trio.

15) (1pt) Circle the species in this trio that is the better nucleophile.
16) (6pts) Assign (R) or (S) to every chiral center in the following molecules.

(a) \( \text{F} \quad \text{H} \quad \text{Br} \quad \text{H} \quad \text{CH}_2\text{Cl} \)

(b) \( \text{CH}_3 \quad \text{CH}_3 \quad \text{C}_6\text{H}_4 \quad \text{H}_3\text{C} \quad \text{CO}_2\text{H} \)

17) (4pts) Draw the mechanism (i.e. using curly arrows) for this electrophilic addition of hydrogen fluoride to cyclopentene.

\[
\text{C}_5\text{H}_6 \quad \text{H-F} \quad \rightarrow \quad \text{C}_5\text{H}_5\text{F}
\]
18) Give the reagents for the following reactions. (6pts)

19) (6pts) Give the products formed in the following transformations of the below cyclic alkene, *paying attention to stereo- and regio-chemistry where relevant.*

1) $\text{CH}_3\text{CO}_3\text{H}$

2) $\text{OsO}_4, \text{H}_2\text{O}_2$

3) i) $\text{BH}_3 \cdot \text{THF}$
   ii) $\text{H}_2\text{O}_2, \text{NaOH}$
**Up to TWO BONUS POINTS**

Provide the opposite of the following chemical terms.

*Inversion* (of stereochemistry)

*Sadtzeff* (product)
1-10 are True / False (10pts)

1) Enantiomers are non-superimposable mirror images.  

2) Single bonds are typically shorter and stronger than double bonds.

3) $S_N2$ reactions generate 100% inversion of stereochemistry because the nucleophile must attack from directly behind the Carbon – Leaving Group bond.

4) (R) or (S) stereocenters are assigned according to rules of the Cahn-Ingold-Prelog convention.

5) An elimination is a reaction where two atoms or groups are removed to produce a new π bond.

6) Hex-1-ene and Cyclohexane are stereoisomers.

7) A diastereomer is a stereoisomer which is not an enantiomer.

8) Saytzeff’s rule states that the major product from an elimination will be the more highly alkyl substituted π bond.

9) A Leaving Group must be a good Proton donor.

10) Hydrogen Bromide and Peroxides is the reagent set used to add H and Cl, with Anti-Markovnikov regiochemistry, with Syn stereochemistry to alkenes.
11) (5pts) Below is Ibuprofen, a nonsteroidal anti-inflammatory drug (NSAID) that is used for treating pain, fever, and inflammation. It is available under trade names, including Advil and Motrin. It is the #1 selling OTC pain reliever in the USA.

\[
\text{\begin{center}
\includegraphics[width=0.5\textwidth]{ibuprofen.png}
\end{center}}
\]

Determine:

a) The number of Carbons. \textbf{13}

b) The number of Hydrogens. \textbf{18}

c) The number of \(\pi\) bonds. \textbf{4}

d) The number of chiral centers. \textbf{1}

e) Based on your answer to (d) – how many different stereoisomers fit the above (imprecise) structural representation?

\[
\begin{align*}
2^1 & = 2
\end{align*}
\]

12) (3+4=7pts) Name these two compounds in IUPAC form.

\[
\begin{align*}
\text{3-fluoro cyclobutene} \\
(3\text{-fluorocyclobutene is acceptable})
\end{align*}
\]

\[
\text{E-1-chloro-2,5-dimethylhex-1-ene}
\]
13) (4pts) Draw in the curly arrows for this acid catalyzed elimination.

\[
\begin{align*}
\text{HOH} & \xrightarrow{\text{H-O-SO-O-H}} \text{HOH} \\
\text{HOH} & \xrightarrow{\text{H-O-SO-O-H}} \text{HOH} \\
\text{H}_2\text{SO}_4 & \xrightarrow{\text{H}_2\text{O}} \text{HOH}
\end{align*}
\]

14) (1pt) Circle the most stable cation in this trio.

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3^+ & \quad \text{CH}_3\text{CH(CH}_3\text{CH}_2\text{CH}_3^+ & \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3^+
\end{align*}
\]

15) (1pt) Circle the species in this trio that is the better nucleophile.

\[
\begin{align*}
\text{HOH} & \quad \text{HO}^- & \quad \text{HOH}
\end{align*}
\]
16) (6pts) Assign (R) or (S) to every chiral center in the following molecules.

(a)  
\[ \begin{array}{c}
\text{CO}_2\text{H} \\
\text{CH}_3 \\
\text{Br} \\
\text{H} \\
\text{CH}_2\text{Cl}
\end{array} \]

(b)  
\[ \begin{array}{c}
\text{CH}_3 \\
\text{H} \\
\text{CO}_2\text{H} \\
\text{for R} \\
\text{for R}
\end{array} \]

17) (4pts) Draw the mechanism (i.e. using curly arrows) for this electrophilic addition of hydrogen fluoride to cyclopentene.

\[ \begin{array}{c}
\text{H-F} \\
\text{cyclopentene} \\
\text{F} \\
\text{F} \\
\text{F}
\end{array} \]
18) Give the **reagents** for the following reactions. (6pts)

![Chemical reaction diagram]

19) (6pts) Give the products formed in the following transformations of the below cyclic alkene, *paying attention to stereo- and regio-chemistry where relevant.*

![Chemical reaction diagram]
**Up to TWO BONUS POINTS**
Provide the opposite of the following chemical terms.

*Inversion* (of stereochemistry)

\[ \text{Retention} \]

*Saytzeff* (product)

\[ \text{Hofmann} \]