Name  

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

1) (6pts) Give one definition of a Nucleophile  

b) Give one definition of an Electrophile  

c) Give one definition of an acid.  

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

Unsaturated Compound  

Chiral Molecule  

Racemic Mixture  

Rate Determining Step  

Anti Addition  

Thermodynamics  

Kinetics  

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

\[ R\text{-O-O-R} \quad R\text{-O-R} \quad R\text{-O-H} \]

\[ \text{O} \quad \text{R} \quad \text{O} \quad \text{H} \quad \text{R} \quad \text{O} \quad \text{O} \quad \text{R} \]

\[ R\text{=}\equiv\text{R} \quad R\text{=}\text{O-O-H} \]

\[ R\text{-S-H} \quad R\text{=}\text{R} \]

4) Draw Lewis structures (lines for bonds and dots for all lone pairs) for the following molecules: (6pts)

(a) \(\text{B(OH)}_3\)  

(b) \(\text{O} \quad \equiv \quad \text{NH} \)
5) (14pts): For the below molecule, calculate the number of…

\[
\text{\[\text{Diagram of molecule}\]\text{}}
\]

a) carbon atoms
b) hydrogen atoms
c) nitrogen atoms
d) rings
e) sp\(^2\) hybridized carbons
f) sp\(^3\) hybridized atoms
g) lone pairs (non bonding pairs) of electrons

6) Explain (including curly arrows) why in this electrophilic addition reaction, none of product A is generated, and product B is formed exclusively. (8pts)

\[
\text{\[\text{Diagram of reaction}\]\text{}}
\]
7) (12pts): For the below energy level diagram…

![Energy Level Diagram]

a) is this reaction exothermic or endothermic?

b) Will the Equilibrium constant (K) 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?

8) Explain why the methyl radical (•CH₃) has H-C-H bond angles of 120°. (7pts)
9) Name the following molecules in IUPAC form. (16pts)

(a) 

(b) 

(c) 

(d) 

(e)
10) Assign R or S to each chiral center in these molecules. (12pts)

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

(b) 
\[
\begin{array}{c}
\text{Br} \\
\text{Br} \\
\text{Cl} \\
\text{CF}_3
\end{array}
\]

(c) 
\[
\begin{array}{c}
\text{OH} \\
\text{H} \\
\text{OH} \\
\text{CH}_2
\end{array}
\]

(d) 
\[
\begin{array}{c}
\text{CH}_2\text{F} \\
\text{CH}_3
\end{array}
\]

11) What is the name of the type of Projection in part (10d) (2pts).

(b) What is meant by the term *diastereomer*? (2pts)
12) (i) Write a mechanism (i.e. curly arrows) for this E1 elimination. (8pts)

\[
\text{Br} \quad \xrightarrow{\text{K}^+ \cdot \text{OCH}_3, \text{CH}_3\text{OH}} \quad \text{H}_2\text{C}=\text{CH}_2
\]

(ii) If four times as much Potassium Butoxide was added, what would happen to the rate of this reaction? (2pts)

13) Circle the more stable member of each pair (8pts)

(a) [ Structures not shown ]

(b) [ Structures not shown ]

(c) [ Structures not shown ]

(d) [ Structures not shown ]
14) In the lowest energy conformation of \textit{trans}-1,2-dimethylcyclohexane, how many axial positions are occupied by Hydrogen atoms? (6pts)

15) Answer the following:
(i) Which three chemists invented the priority convention for assigning R and S chirality? (2pts)

(ii) State the Hammond Postulate. (2pts)

(iii) Explain the difference between \textit{stereoisomers} and \textit{structural isomers}. Provide an example of both types. (6pts)
16) Give the reagents for **5 of the 6** following reactions of cyclohexene. (15pts)

![Diagram of cyclohexene reactions]

16b) Write the mechanism for **one** of the preceding reactions. (10pts)
17) Give the products in 5 of the 6 following transformations. (15pts)

17b) Write the mechanism for one of the preceding reactions. (10pts)
**Bonus questions** (up to 2 + 2 points).

List two everyday chiral objects (but not parts of the body or clothing items).

List two examples of common processes that involve an increase in entropy.
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1) (6pts) Give one definition of a Nucleophile
   A two electron donor; a Lewis base.

b) Give one definition of an Electrophile
   A two electron acceptor; a Lewis Acid

c) Give one definition of an acid.
   $H^+$ dons $I$, dissolves to give $H_3O^+$, electron pair acceptor

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

**Unsaturated Compound**
Does not have the maximum number of bonds to Hydrogens (Contains rings and/or \( \pi \) bonds).

**Chiral Molecule**
Has a non-superimposable mirror image.

**Racemic Mixture**
A mixture with both enantiomers of a Chiral Molecule.

**Rate Determining Step**
The slowest step of a multistep process.

**Anti Addition**
Addition of two atoms or groups on opposite faces of a \( \pi \) bond.

**Thermodynamics**
The study of energy changes during a reaction.

**Kinetics**
The study of rates of reactions.

**\( \pi \) Bond**
Sideways overlap of orbitals to form a covalent bond.
3) Name the classes of compound that the following molecules belong to (E.g. alkane, amide, etc). (15pts)

\[ \text{Peroxide} \quad \text{Ethyl} \quad \text{Alcohol} \]

\[ \text{Carboxylic Acid} \quad \text{Aldehyde} \quad \text{Ester} \]

\[ \text{Alkyne} \quad \text{Peroxide} \quad \text{Ketone} \]

\[ \text{Thiol} \]

4) Draw Lewis structures (lines for bonds and dots for all lone pairs) for the following molecules: (6pts)

(a) \[ \text{B(OH)}_3 \]

(b) \[ \text{NH} \]

\[ \text{H-O-B-O-H} \]

\[ \text{H-C-S-H} \]

\[ \text{H-C=S-H} \]
5) (14pts): For the below molecule, calculate the number of...

![Chemical Structure]

a) carbon atoms 10
b) hydrogen atoms 14
c) nitrogen atoms 2
d) rings 2
e) \(sp^2\) hybridized carbons 5
f) \(sp^3\) hybridized atoms 6
g) lone pairs (non bonding pairs) of electrons 2

6) Explain (including curly arrows) why in this electrophilic addition reaction, none of product A is generated, and product B is formed exclusively. (8pts)

![Chemical Reaction]

This primary cation is unstable and is not produced.

This cation is tertiary and the alkyl substituents stabilize the +Ve charge.

This is the more stable, preferred cation which gets produced.

This is an example of Markownikov orientation.
7) (12pts): For the below energy level diagram...

![Energy Level Diagram]

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

b) Will the Equilibrium constant (K) be greater or less than 1.00?  **Less than 1**

c) how many transition states are there?  **2**

d) how many steps is this multistep reaction?  **2**

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

f) which is the fastest step?  **1st**

8) Explain why the methyl radical (•CH₃) has H-C-H bond angles of 120°. (7pts)

- C has 3σ bonds & 2π lone pairs
- \( sp² \) hybridization

- \( sp² \) hybridization creates three hybrid orbitals which are planar and spaced by 120°

- The radical electron occupies the remaining unhybridized \( p \) orbital.
9) Name the following molecules in IUPAC form. (16pts)

(a) \( \text{Cl} \) 
1-CHLOROPROPANE

(b) \( \text{CH}_{3} \)
4-METHYL-1-PENTYNE

(c) \( \text{HO} \)
ANTI-4-CHLOROCYCLOHEXANOL

(d) \( \text{CH}_{3}\text{CH}_{2}\text{CH}_{2}\text{CH}_{2}\text{Br} \)
Z-1-BROMO-4-OCTENE

(e) \( \text{Cl} \)
ANTI-3-CHLOR-1-IODOCYCLOBUTANE
10) Assign R or S to each chiral center in these molecules. (12pts)

(a) 
\[ \begin{array}{c}
\text{Cl} \quad \text{OH} \\
\text{CH}_3 \\
\end{array} \]

(b) 
\[ \begin{array}{c}
\text{Br} \quad \text{Br} \\
\text{Cl} \quad \text{H} \\
\text{CF}_3 \\
\end{array} \]

(c) 
\[ \begin{array}{c}
\text{HO} \\
\text{OH} \\
\text{CH}_2 \\
\end{array} \]

(d) 
\[ \begin{array}{c}
\text{HOCH}_2 \quad \text{OH} \\
\text{H} \\
\text{CH}_2\text{F} \\
\text{CH}_3 \\
\end{array} \]

11) What is the name of the type of Projection in part (10d) (2pts).

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

A stereoisomer which is not an enantiomer.
12) (i) Write a mechanism (i.e. curly arrows) for this E1 elimination. (8pts)

(ii) If four times as much Potassium Butoxide was added, what would happen to the rate of this reaction? (2pts)

No change

13) Circle the more stable member of each pair (8pts)

(a)  

(b)  

(c)  

(d)  

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14) In the lowest energy conformation of trans-1,2-dimethylcyclohexane, how many axial positions are occupied by Hydrogen atoms? (6pts)

\[ \text{Di-Equatorial} \quad \text{Di-Axial} \]

- LOWER ENERGY
- HIGHER ENERGY

\[ \therefore 6 \text{ AXIAL HYDROGENS.} \]

15) Answer the following:
(i) Which three chemists invented the priority convention for assigning R and S chirality? (2pts)

CAHN  INGOLD  PRELOG

(ii) State the Hammond Postulate. (2pts)

For related processes, species of similar energy will be of similar structure.

(iii) Explain the difference between stereoisomers and structural isomers. Provide an example of both types. (6pts)

Isomers are compounds that have the same molecular formulas but are different.

Structural isomers have different bond connectivities.

\[ \text{E} \] 
\[ \text{Z} \]

Stereoisomers have the same bond connectivity but differ in the three-dimensional arrangement in space.

\[ \text{E} \] 
\[ \text{Z} \] 

\text{E}g. \quad \text{C}_5\text{H}_{10} \]

\text{Example:} \quad \text{C}_5\text{H}_{10} \]
16) Give the reagents for **5 of the 6** following reactions of cyclohexene. (15pts)

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<th>Reaction Product</th>
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<tbody>
<tr>
<td>H-Cl</td>
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<tr>
<td>mcpba</td>
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<tr>
<td>Cl₂, H₂O</td>
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<td>H₂Pt</td>
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<td>H₂SO₄, H₂O</td>
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<td>Br₂</td>
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16b) Write the mechanism for **one** of the preceding reactions. (10pts)

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<thead>
<tr>
<th>Mechanism Step</th>
<th>Reaction Product</th>
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<tbody>
<tr>
<td>H-Cl</td>
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<td>Cl⁺</td>
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17) Give the products in 5 of the 6 following transformations. (15pts)

17b) Write the mechanism for one of the preceding reactions. (10pts)
**Bonus questions** (up to 2 + 2 points).

List two everyday chiral objects (but not parts of the body or clothing items).

Golf club, scissors, spiral staircase, screw.

List two examples of common processes that involve an increase in entropy.

- Go to sleep with your hair really styled, I wake up and it's a mess.
- Leave your garden unattended and it becomes disordered.