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

b) Give one definition of a base

c) What is an Electrophile?

2) Briefly explain what is meant the following terms:(16pts total)
Free radical
Chiral Molecule
Racemic Mixture
Rate Determining Step
Syn Addition
Mechanism
Kinetics
Terminal alkyne
3) Name the classes of compound that the following molecules belong to (E.g. alkane, amide, etc). (15pts)

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

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

\[
\begin{align*}
\text{O} & \quad \text{O-CH}_3 \\
\text{O} & \quad \text{R} \\
\text{R} & \quad \text{O} \\
\text{O} & \quad \text{R} \\
\end{align*}
\]

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

(a) \[
\begin{array}{c}
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array} \rightarrow \begin{array}{c}
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array}
\]

(b) \[
\begin{array}{c}
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array} \rightarrow \begin{array}{c}
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array}
\]

(c) \[
\begin{array}{c}
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array} \rightarrow \begin{array}{c}
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array}
\]

(d) \[
\begin{array}{c}
\text{H}_3C \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array} \rightarrow \begin{array}{c}
\text{H}_3C \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array}
\]

(e) \[
\begin{array}{c}
\text{H}_3C \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array} \rightarrow \begin{array}{c}
\text{H}_3C \\
\text{H} \\
\text{H} \\
\text{Ph} \\
\text{H}_3C \end{array}
\]

7) Explain why in this electrophilic addition reaction, none of product A is generated, and product B is formed exclusively. (9pts)

Product A

Product B
8) Draw an energy level diagram for a typical exothermic $S_N1$ process. Make sure to label (a) the axes (b) the reactants and products (c) any transition states (d) $\Delta H^o$ for the overall reaction (e) the rate determining step (9pts)

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

(a) 

(b) 

(c) 

(d) 

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

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

(b) 
\[ \text{O} \quad \text{H} \quad \text{NHCH}_3 \quad \text{H} \quad \text{CH}_3 \]

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

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

12) What is the name of the type of Projection used in part (d). (2pts)

(b) State one advantage of this type of drawing over normal sticks and wedges (2pts)
13) Explain mechanistically the observation that when Br$_2$ is added to cyclohexene, the Bromine atoms end up anti to one another. (10pts)

\[ \text{cyclohexene} + Br-Br \rightarrow \text{anti dibromide} \]

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

(i) Explain and draw what the chair conformation is (5pts)

(ii) Explain what ‘equatorial’ is (3pts)
(iii) Explain why it is energetically preferred to put the substituent equatorial. (6pts)

15) Answer the following:
(i) State two characteristics of an E2 reaction. (2pts)

(ii) State two characteristics of an S_N1 reaction. (2pts)

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

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)
Fall 01 Organic I Final Exam

Name: SELMA SOUL-TWOPASS

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

1) (5pts total) Give one definition of an Acid
   Proton donor / gives H3O+ in water / 2 electron acceptor

b) Give one definition of a base
   Proton acceptor / gives OH in water / 2 electron donor

c) What is an Electrophile?
   Two electron acceptor

2) Briefly explain what is meant the following terms: (16pts total)
   Free radical
   Species with an odd number of valence electrons.

   Chiral Molecule
   A molecule with a non-superimposable mirror image.

   Racemic Mixture
   Equal amounts of two enantiomers

   Rate Determining Step
   The slowest step in a multistep process

   Syn Addition
   Addition of two atoms/groups to the same side of what was a multiple bond

   Mechanism
   Step by step movement of electrons describing a reaction

   Kinetics
   The study of reaction rates.

   Terminal alkyne
   A compound with a -C≡C-H unit.
3) Name the classes of compound that the following molecules belong to (E.g. alkane, amide, etc). (15pts)

- \( R\text{-CHO} \) \( \text{aldehyde} \)
- \( R\text{-COOH} \) \( \text{carboxylic acid} \)
- \( R\text{-COOR} \) \( \text{ester} \)
- \( R\text{-C\equiv-C} \) \( \text{alkyne} \)
- \( R\text{-COOHO} \) \( \text{peroxy acid} \)
- \( R\text{-S\text{-H}} \) \( \text{thiol} \)
- \( R\text{-COR} \) \( \text{ketone} \)
- \( R\text{-O\text{-O\text{-R}}} \) \( \text{peroxide} \)
- \( R\text{-OR} \) \( \text{ether} \)
- \( R\text{-OH} \) \( \text{alcohol} \)

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

- [Lewis structure of compound 1]
- [Lewis structure of compound 2]

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

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

(a) \[ \text{ Cyclohexane } \rightarrow \text{ Cyclohexanol } \]

(b) \[ \text{ H}_3\text{C} - \text{F} \cdots \text{CH}_3 \rightarrow \text{ H}_3\text{C} - \equiv - \text{CH}_3 \]

(c) \[ \text{ Ph} \cdots \text{H} \rightarrow \text{ Ph} \cdots \text{H} \cdots \text{Br} \]

(d) \[ \text{ H}_3\text{C} - \equiv - \text{CH}_3 \rightarrow \text{ H}_3\text{C} - \text{H} \cdots \text{Cl} \cdots \text{CH}_3 \]

(e) \[ \text{ H}_3\text{C} \cdots \text{CH}_3 \rightarrow \text{ H}_3\text{C} - \text{CH}_2\text{OH} \]

7) Explain why in this electrophilic addition reaction, none of product A is generated, and product B is formed exclusively. (9pts)

Product A

Product B

Secondary Cation
Less Stable
Not Formed

Tertiary Cation
More Stable
Preferred Product
8) Draw an energy level diagram for a typical exothermic SN1 process. Make sure to label (a) the axes (b) the reactants and products (c) any transitions states (d) ΔH° for the overall reaction (e) the rate determining step (9pts)

9) By considering the hybridization of the central atom, predict the shapes and bond angles of CH₃⁺ and H₃O⁺. (10pts)
10) Name the following molecules in IUPAC form. (16pts)

(a) 1-Chlorobutane

(b) 5-bromo-3-ethyl-2E-Pentene

(c) Trans 3-Chloro-1-iodo Cyclobutane

(d) 4-Methyl-hex-1yne

(e) Trans 4-Chlorocyclohexanol
11) Assign R or S to each chiral center in these molecules. (12pts)

(a)

(b)

(c)

(d)

12) What is the name of the type of Projection used in part (d). (2pts)

Fisher

(b) State one advantage of this type of drawing over normal sticks and wedges (2pts)

- Useful for molecules with many chiral centres
- Can assign R or S directly.
13) Explain mechanistically the observation that when Br₂ is added to cyclohexene, the Bromine atoms end up anti to one another. (10pts)

The intermediate carbocation exists as the more stable bromonium ion. The Br⁺ must do a ring opening with backside attack, and thus the Bromines end up on opposite sides.

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

(i) Explain and draw what the chair conformation is (5pts)

(ii) Explain what 'equatorial' is (3pts)
(iii) Explain why it is energetically preferred to put the substituent equatorial. (6pts)

It minimizes electron/ electron repulsions by being further away from the rest of the molecule.

EQ The axial position suffers from 1,3 diaxial interaction

15) Answer the following:
(i) State two characteristics of an E2 reaction. (2pts)
- Bimolecular reaction
- Base strength important
- Elimination reaction
- No cation formation
- Stereospecific

(ii) State two characteristics of an S_N1 reaction. (2pts)
- Unimolecular reaction
- Substrate reactivity
- No cation formation
- Nucleophile strength unimportant

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

Structural isomers have same molecular formula but different bond connectivity

\[ \text{H}_2\text{C} = \text{CH}_2 \quad \text{&} \quad \text{CH}_3\text{CH} = \text{CH}_2 \]

Stereoisomers have same molecular formula, same bond connectivity but different three dimensional arrangement of atoms

\[ \text{cis-} \quad \text{&} \quad \text{trans-} \]
16) Give the reagents for 5 of the 6 following reactions of cyclohexene. (15pts)

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)