(1 a-j) are TRUE/FALSE (10pts)

a) A nucleophile is a two electron donor.

b) An sp² hybridized atom still has one unhybridized p orbital.

c) Butane and cyclobutane have different molecular formulas.

d) A Lewis acid is a two electron acceptor.

e) A chiral molecule has a non-superimposable mirror image.

f) An ester is a functional group produced by substituting an OH section in a particular acid, with an OR group.

g) An anion has a negative charge.

h) Deprotonation of terminal alkynes generates the corresponding acetylide anions.

i) π bonds are formed by the sideways overlap of aligned p orbitals on adjacent atoms.

j) A racemic mixture is one that contains both possible enantiomers of the product.

2) Define the following terms (2+2=4pts):

Isomer

Elimination reaction
3) Name the classes of compound (functional group) that the following molecules belong to (e.g. alkane). (6pts)

\[
\begin{align*}
\text{R-C=O} & \quad \text{O} \\
\text{R-O-R} & \quad \text{R-O} \\
\text{R-SH} & \quad \text{R} \\
\text{R-O-H} & \quad \text{R-C=O} \\
\text{R-C=H} & \quad \text{R-C=H}
\end{align*}
\]

4) Write a mechanism (i.e. curly arrows) for this alkyne addition reaction. (4+1+1=6pts)

\[
\begin{align*}
\text{H}_3\text{C-CH} & \quad \text{H-Cl} \quad \text{H}_3\text{C-C}=\text{C-CH}_3 \\
\text{H}_3\text{C} & \quad \text{Cl}^- \quad \text{H}_3\text{C-C}=\text{C-CH}_3 \quad \text{Cl}^-
\end{align*}
\]

Would you expect this overall reaction to be exothermic or endothermic?

Do you think the rate determining (rate limiting) step will be the first or the second step?
5) Name the following molecules in IUPAC form. (12pts)

(a) \[ \text{Structure Image} \]

(b) \[ \text{Structure Image} \]

(c) \[ \text{Structure Image} \]

6) Assign (R) or (S) to every chiral center in these molecules. (6pts)

(a) \[ \text{Structure Image} \]

(b) \[ \text{Structure Image} \]
7) (3pts) For cyclopentanol:

How many Carbons are there?

How many Hydrogens?

What is the hybridization of the Carbons?

8) Write a mechanism (i.e. curly arrows) for this E2 elimination. (4+1+1=6pts)

\[
\begin{array}{c}
\text{K OCH}_2\text{CH}_3 \\
\text{CH}_3\text{CH}_2\text{OH}
\end{array}
\]

Is the regiochemistry of this elimination Saytzeff or Hoffman?

Is the product alkene E, Z or neither?
9) Circle the most stable member of each set. (6pts)

(a)

(b)

(c)

(d)

(e)

(f)
10) The following alcohol will undergo $S_N1$ reaction with HBr, as shown below.

\[ \text{HOH} \quad \text{H-Br} \quad \text{HBr} \quad \text{H}_2\text{O} \]

In the space below write the mechanism (i.e. curly arrows) for this $S_N1$ process, and remember there is a reason why acidic conditions are essential for this reaction to occur. (5pts)

11) (2+2=4pts) In both parts provide:

Two different structural isomers of Butyne.

Two different stereoisomers of But-2-ene.
12) Give the reagents for the following alkene reactions. (10pts)

13) Draw the products for the following transformations. (8pts)
14) Give the reagents (for a, b & d), and the products (for c & e). (10pts)

a) \( \text{H}_3\text{C}-\text{C}=\text{C}-\text{H} \) \( \xrightarrow{\text{Br}} \) \( \text{H}_3\text{C} \)
 \[ \begin{array}{c}
\text{Br} \\
\text{Br} \\
\text{Br} \\
\text{H}
\end{array} \]

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

c) \( \text{H}_3\text{C}-\text{C}=\text{C}-\text{H} \) \( \xrightarrow{i) \text{R}_2\text{BH}} \) \( \text{H}_2\text{O}_2, \text{NaOH} \)

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

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

15) Draw in the arrows for the following mechanism of a Williamson ether synthesis. (4pts)

\( \text{Na}^+ : \text{NH}_2 \)
\( \xrightarrow{\oplus} \)
\( \text{Na}^+ : \text{NH}_3 \)

\( \xrightarrow{\text{Cl}} \)

\( \text{Na}^+ \)

\( \text{Cl}^- \)
***BONUS POINTS (up to THREE)***

Provide a way to achieve this following (multistep) transformation.
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The periodic table of elements is shown with atomic numbers and atomic weights. The lanthanide series is highlighted, spanning from La to Lu.
(1 a-j) are TRUE/FALSE (10pts)

a) A nucleophile is a two electron donor.  

b) An sp² hybridized atom still has one unhybridized p orbital.  

c) Butane and cyclobutane have different molecular formulas. 

d) A Lewis acid is a two electron acceptor.  

e) A chiral molecule has a non-superimposable mirror image.  

f) An ester is a functional group produced by substituting an OH section in a particular acid, with an OR group.  

g) An anion has a negative charge.  

h) Deprotonation of terminal alkynes generates the corresponding acetylide anions.  

i) π bonds are formed by the sideways overlap of aligned p orbitals on adjacent atoms.  

j) A racemic mixture is one that contains both possible enantiomers of the product.

2) Define the following terms (2+2=4pts):

Isomer  Some molecular formula but different.  

Elimination reaction  Removal of two atoms or groups from adjacent atoms forming a new π bond.
3) Name the classes of compound (functional group) that the following molecules belong to (e.g. alkane). (6pts)

- Ester
- Epoxide
- Thiol
- Ketone
- Carboxylic Acid
- Aldehyde

4) Write a mechanism (i.e. curly arrows) for this alkyne addition reaction. (4+1+1=6pts)

Would you expect this overall reaction to be exothermic or endothermic?

- Exothermic

Do you think the rate determining (rate limiting) step will be the first or the second step?

- First
5) Name the following molecules in IUPAC form. (12pts)

(a) \((E)-1\text{-fluoro-}1\text{-ene}\)

(b) Cis-1,3-Dimethyl cyclohexane

(c) 4-Methyl-pent-3-yne

6) Assign (R) or (S) to every chiral center in these molecules. (6pts)

(a) \(\text{H}_3\text{C} - \text{CH}_3 - \text{CO}_2\text{H}\) R

(b) F

CH\text{Cl}
7) (3pts) For cyclopentanol:

   How many Carbons are there? 5
   How many Hydrogens? 10
   What is the hybridization of the Carbons? $\text{sp}^3$

8) Write a mechanism (i.e. curly arrows) for this E2 elimination. (4+1+1=6pts)

   Is the regiochemistry of this elimination Saytzeff or Hoffman?

   Is the product alkene E, Z or neither?
9) Circle the most stable member of each set. (6pts)

(a) 

(b) 

(c) 

(d) 

(e) 

(f)
10) The following alcohol will undergo $S_{N}1$ reaction with HBr, as shown below.

\[
\begin{align*}
\text{OH} & \quad \text{H-Br} & \quad \text{Br} \\
\text{H}_2\text{O} & \quad \text{carbocation}
\end{align*}
\]

In the space below write the mechanism (i.e. curly arrows) for this $S_{N}1$ process, and remember there is a reason why acidic conditions are essential for this reaction to occur. (5pts)

11) (2+2=4pts) In both parts provide:

Two different **structural** isomers of *Butyne*.

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

Two different **stereoisomers** of *But-2-ene*.

\[\begin{align*}
\text{\ include two different stereoisomers of \text{But-2-ene.}}
\end{align*}\]
12) Give the reagents for the following alkene reactions. (10pts)

13) Draw the products for the following transformations. (8pts)
14) Give the reagents (for a, b & d), and the products (for c & e). (10pts)

a) \[ \text{H}_3\text{C} = \text{C} = \text{C} = \text{H} \xrightarrow{2 \text{equiv. } \text{Br}_2} \]

b) \[ \text{O} \]

\[ \text{CH}_3\text{CH}_2\text{MgBr} \] \[ \xrightarrow{3\text{ H}_2\text{O}} \]

c) \[ \text{H}_3\text{C} = \text{C} = \text{C} = \text{H} \]

\[ \xrightarrow{i) R_2BH \quad \text{ ii) } H_2O_2, \text{NaOH} \]

d) \[ \text{O} \]

\[ \text{NaBH}_4 \]

\[ \xrightarrow{3\text{ H}_2O} \]

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

15) Draw in the arrows for the following mechanism of a Williamson ether synthesis. (4pts)

![Mechanism Diagram]

\[ \text{Na} \quad \text{NH}_2 \]

\[ \text{Cl} \]

\[ \text{Na} \]

\[ \text{NH}_3 \]
***BONUS POINTS (up to THREE)***

Provide a way to achieve this following (multistep) transformation.

\[ \text{CH}_3\text{MgBr} \xrightarrow{\text{CH}_3\text{CO}_2\text{H}} \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \xrightarrow{\text{PyrIDine, Ts-CI}} \text{CH}_3\text{CH}_2\text{CH}_2\text{OTs} \]