1) (6pts) Assign (R) or (S) to all the chiral centers in the following molecules.

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

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

(c) \[
\begin{array}{c}
\text{NH} \\
\text{CH}_3 \\
\text{CH}_3 \\
\text{H} \\
\text{H} \\
\text{H}_3\text{C} \\
\text{OH}
\end{array}
\]

2) (4pts) Explain what is meant by these two terms:
(a) Enantiomer

(b) Racemic mixture
3) (12pts) (i) All alkenes have one thing in common, name that feature.

(ii) Identify the hybridization of each carbon in the butene molecule below.

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

(iii) Explain which orbitals create the $\pi$ bond, and draw a picture of how they overlap to create the $\pi$ bond.

(iv) is the butene above the cis or trans isomer?

(v) is the butene above the Z or E isomer?
4) (5pts) Name this compound in IUPAC form.

\[
\begin{array}{c}
\text{Br} \\
\end{array}
\]

5) (10pts) Answer the following:
(i) State two characteristics of an E1 reaction.

(ii) State two characteristics of an S\textsubscript{N}2 reaction.

(iii) State the Saytzeff rule for an elimination reaction.

(iv) State the Markovnikov rule for addition of HX to a carbon-carbon double bond.
6) (6pts) Draw trans-1,3-dibromo-1-ethylcyclopentane.

7) (18pts) The alcohol below can form three different alkene products (via dehydration) when it reacts with concentrated sulfuric acid proceeding through the E1 mechanism.

(i) Draw the three different products.

(ii) Provide a mechanism for the formation of each product.
8) (22pts) Write above the arrow the best reagents to use for each of the following transformations.

(a) \( \text{H} \text{CH}_{3}\text{CH}_{2}\text{CH}_{2}\text{CH}_{3} \rightarrow \text{H} \text{CH}_{2}\text{CH}_{3}\text{CH}_{2}\text{CH}_{3} \)

(b) \( \text{H} \text{C}_{6}\text{H}_{4} \rightarrow \text{H} \text{OH} \)

(c) \( \text{H} \text{CH}_{3}\text{CH}_{2}\text{CH}_{3} \rightarrow \text{CH}_{3}\text{CH}_{2}\text{CH}_{3} \)

(d) \( \text{C}_{6}\text{H}_{5} \rightarrow \text{C}_{6}\text{H}_{5} \)

(e) \( \text{C}_{6}\text{H}_{5} \rightarrow \text{C}_{6}\text{H}_{5} \text{CO}_{2}\text{H} \)

(f) \( \text{C}_{6}\text{H}_{5} \rightarrow \text{C}_{6}\text{H}_{5} \)

9) (2pts) What is the basic difference between *hydration* and *hydroxylation*?

10) (2pts) Explain briefly what the difference between a *syn* addition and an *anti* addition is.

11) (3pts) Explain briefly what is meant by the *peroxide effect* in the addition of H-Br to alkenes?

12) (10pts) Explain why when HBr is added to ethene a carbocation intermediate is formed, yet when Br₂ is added to ethene a three membered bromonium ion intermediate is formed.

\[
\begin{align*}
\text{H}_2\text{C}=&\text{CH}_2 & \text{Br-Br} & \rightarrow & \text{H}_2\text{C}=&\text{CH}_2 \text{ Br}^+ \\
\downarrow & & \downarrow & & \downarrow \\
\text{H}-\text{Br} & & & & \text{Br}^- \\
\text{H}_3\text{C}=&\text{CH}_2 & & \text{Br}^- \\
\end{align*}
\]
Answer all the questions.

1) (6pts) Assign (R) or (S) to all the chiral centers in the following molecules.

(a) 

(b) 

2) (4pts) Explain what is meant by these two terms:
(a) Enantiomer

A non-superimposable mirror image isomer.

(b) Racemic mixture

A mixture that contains equal amounts of the (R) and (S) enantiomers.
3) (12pts) (i) All alkenes have one thing in common, name that feature.

A carbon-carbon double bond

(ii) Identify the hybridization of each carbon in the butene molecule below.

(iii) Explain which orbitals create the π bond, and draw a picture of how they overlap to create the π bond.

A carbon-carbon double bond is formed when two unbonded p orbitals overlap in a sideways fashion.

(iv) is the butene above the cis or trans isomer?

Cis

(v) is the butene above the Z or E isomer?

Z
4) (5pts) Name this compound in IUPAC form.

\[ \text{5-Bromo-2-methyl-(2,4E)-heptadiene} \]

5) (10pts) Answer the following:
(i) State two characteristics of an E1 reaction.
- Elimination
- Unimolecular
- Carbon Intermediate
- C+ rearrangements
- Weak base

(ii) State two characteristics of an S_N2 reaction.
- Nucleophilic Substitution
- Bimolecular
- Strength of nucleophile important
- Stereospecific
- Always inversion of stereochemistry

(iii) State the Saytzeff rule for an elimination reaction.
The major product of an elimination will be the more highly substituted alkene.

(iv) State the Markovnikov rule for addition of HX to a carbon-carbon double bond.
We: H-X adds to a double bond, the electrophile (H+) binds to the least substituted end, while the nucleophile (X-) binds to the most highly substituted end.

\[ \text{Or} \]

The electrophile adds in such a way so as to generate the most stable intermediate.
6) (6pts) Draw trans-1,4-dibromo-1-ethylcyclopentane.

7) (18pts) The alcohol below can form three different alkene products (via dehydration) when it reacts with concentrated sulfuric acid proceeding through the E1 mechanism.

(i) Draw the three different products.

(ii) Provide a mechanism for the formation of each product.
8) (22pts) Write above the arrow the best reagents to use for each of the following transformations.

(a) $\text{H} \quad \text{CH}_2\text{CH}_3 \quad \text{H-F} \quad \text{H} \quad \text{CH}_2\text{CH}_3$

(b) $\text{C}_8\text{H}_{16}$ \quad $\text{O}_3\text{C} + \text{H}_2\text{O}$ \quad $\text{C}_8\text{H}_{17}$

(c) $\text{CH}_3\text{CH}_2 \quad \text{BH}_3 + \text{H}_2\text{O}/\text{OH}$ \quad $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

(d) $\text{C}_8\text{H}_{16}$ \quad $i) \text{RCO}_2\text{H}$ \quad $\text{C}_8\text{H}_{17}$ \quad $a) \text{H}_2\text{O}/\text{H}^+$

(e) $\text{C}_5\text{H}_{10}$ \quad $\text{KMnO}_4$, heat \quad $\text{C}_5\text{H}_{10}$ \quad $\text{HO}_2\text{C} \quad \text{CO}_2\text{H}$

(f) $\text{C}_5\text{H}_{10}$ \quad $\text{H}_2 / \text{Pt}$ \quad $\text{C}_5\text{H}_{10}$
9) (2pts) What is the basic difference between hydration and hydroxylation?

Hydration is the addition of H₂O across a double bond, whereas hydroxylation is the addition of OH⁻ across a double bond.

10) (2pts) Explain briefly what the difference between a syn addition and an anti addition is.

A syn addition is where both groups are added to the same face of a double bond, whereas anti has them on opposite faces.

11) (3pts) Explain briefly what is the meant by the peroxide effect in the addition of H-Br to alkenes?

This allows the generation of anti Markonnikov allyl bromides to be formed, using above + HBr + heat.

The peroxide generates Br₂ which add to the double bond.

12) (10pts) Explain why when HBr is added to ethene a carbocation intermediate is formed, yet when Br₂ is added to ethene a three membered bromonium ion intermediate is formed.

Both undergo attack by the 1T electrons of the double to generate a carbocation.

The lone pair on Br can bond to the carbocation forming a bromonium ring, which is more stable than the carbocation (due to an extra σ bond).