16. Give structures for each of the following compounds or ions:

- Oxonium ion
  \[H_3O^+ \quad (H-O-H)\]
- Any chloronium ion (cyclic)
  \[\text{C-C-C}\]

- Thionyl chloride
  \[\text{Cl-S-Cl}\]

- (Z)-1-methyl-1,2-cyclopentanediol

- cis-2-bromo-3-pentene
  \[\text{B} \quad \text{C-C-C-C} \quad (\text{C-C}\text{C-H})\]

- (Z)-1-fluoro-2-chloropropene
  \[\text{C-C=C} \quad \text{H} \quad \text{F}\]

- Isopentyl carbocation
  \[\text{C} \quad \text{C-C-C-C} \quad \Theta\]

- A 6-carbon conjugated diene
  \[\text{C-C=C=C=C}\]

12. (i) Acid-catalyzed elimination reactions often produce more than one product. Show the elimination reaction of an alcohol where you could produce at least 4 different products (show their structures), which may involve a hydride or methyl shift in the process (6 pts). (ii) Give the names for each product (1 pts ea) (iii) Predict which would be the major product (2 pts).
3. We have usually started with a reactant and showed the product. However, organic chemists are often given a product, and have to determine a good reactant. For the following products, show a single (and only one) alkene that could be used to make the desired product(s). Include any other chemicals (acid, base, water, catalyst, etc.) that could be required. *(You may want to draw the structure of the product in order to give yourself a better idea for the structure of the potential alkene which could be used.)*

- Isobutyl alcohol (\(1^\circ\) Alcohol)

- 1-bromo-2-pentanol (halohydrin)

- 4-methyl-2-pentanol (\(2^\circ\) Alcohol)

- 2-bromopropane

4. (i) Show the complete reaction mechanism (with arrows) and the correct product for the reaction of 1-pentene and HBr, including the carbocation which is formed. (ii) Show the product *(but no reaction mechanism is necessary)* for reaction of HBr and 1-pentene in the presence of peroxides. (iii) Explain why peroxides lead to anti-Markovnikov addition for HBr.

\[
\begin{align*}
(\text{I}) & \quad \text{C-C-C-C=C + HBr} \rightarrow \text{C-C-C-C=C + Br} - \rightarrow \text{C-C-C-C-Br} \\
(\text{II}) & \quad \text{C-C-C-C-Br}
\end{align*}
\]

\[(\text{III}) \quad \text{Peroxides lead to anti-Markovnikov addition of HBr because it goes through free radical and 2° free radical more stable} \]
10 6. (i) Hydration of propene is regioselective. Show the reaction mechanism by which hydration takes place and explain why you get a single product (4 pts). (ii) Show the reaction mechanism by which Br₂ reacts with cyclohexene. Be sure to include the intermediate bromonium ion (3-membered ring with a positive charge) (4 pts). (iii) What is the evidence for an anti addition mechanism during halogenation reactions (2 pts).
7. (i) BH₃ can be used to produce primary alcohols. Show the initial reaction mechanism when BH₃ reacts with propene, up to and including the first hydride ion transfer. (ii) What will be the ultimate structure for the alcohol produced following the complete hydroboration-oxidation process? (iii) Explain why hydroboration-oxidation leads to an alcohol with anti-Markovnikov orientation, compared to normal acid-catalyzed hydration.

8. (i) Starting with sec-butyl alcohol, show the complete reaction mechanism required to produce a carboxylate in acidic conditions. (ii) If this reaction occurred in the presence of sulfuric acid, show how E1 elimination could occur. (iii) If a carbocation was formed in HCl(aq), show the product and explain why substitution occurs, not elimination.

9. If you undergo elimination of 2-butanol, show the products and indicate which is the major and which is the minor product. Justify your answer based on Zaitsev's rule and other requirements.