Multiple Choice Questions. 60 points Select the best answer to each of the questions.

1. Choose the compound produced by the 1,4-free radical addition of H-Br to the following diene.

   ![Diene and Reaction](image)

   - A
   - B
   - C
   - D
   - E
   
   Select: C

2. Choose the reactants that would give the following Diels-Alder product.

   ![Diels-Alder Reaction](image)

   - A
   - B
   - C
   - D
   - E
   
   Select: A

3. Choose the order that has the following compounds correctly ordered with respect to increasing reactivity with respect to a solvolysis ($S_{N1}$) reaction.

   ![Solvolysis Reaction](image)

   - i
   - ii
   - iii
   - i < ii < iii
   - i < iii < ii
   - ii < iii < i
   - ii < i < iii
   - iii < i < ii
   - Increasing reaction rate

   Select: A
4. Choose the best reaction sequence for the preparation of 4-bromopropylbenzene.

\[
\text{1-bromo-4-propylbenzene}
\]

A. 

\[
\text{Br}_2 \rightarrow \text{Cl} \rightarrow \text{AlCl}_3 \rightarrow \text{FeBr}_3
\]

B. 

\[
\text{Cl} \rightarrow \text{Br}_2 \rightarrow \text{AlCl}_3 \rightarrow \text{FeBr}_3
\]

C. 

\[
\text{Cl} \rightarrow \text{Br}_2 \rightarrow \text{Zn(Hg)} \rightarrow \text{HCl} \rightarrow \text{AlCl}_3
\]

D. 

\[
\text{Cl} \rightarrow \text{Br}_2 \rightarrow \text{FeBr}_3 \rightarrow \text{AlCl}_3 \rightarrow \text{HCl}
\]

E. 

\[
\text{Br}_2 \rightarrow \text{Cl} \rightarrow \text{Zn(Hg)} \rightarrow \text{HCl} \rightarrow \text{AlCl}_3
\]

5. Choose the order that has the following compounds correctly arranged with respect to bromination (Br$_2$/FeBr$_3$).

\[
i \quad \text{OH} \quad \text{Cl} \\
ii \quad \text{iii}
\]

\[
i < ii < iii \\
i < iii < ii \\
ii < iii < i \\
i < i < iii \\
iii < i < ii
\]

6. Choose the order that has the following molecular orbitals correctly arranged with respect to increasing energy (least stable MO would be on the right).

\[
i \quad \text{ii} \quad \text{iii}
\]

\[
i < ii < iii \\
i < iii < ii \\
ii < iii < i \\
i < i < iii \\
iii < i < ii
\]
7. From an inspection of the contributing resonance structures choose the order that has the following compounds correctly arranged with respect to increasing stability due to electron delocalization.

\[
i < ii < iii
\]

8. Choose the order that has the following compounds correctly arranged with respect to increasing acidity.

\[
i < ii < iii
\]

9. Choose the best single structure for the intermediate in the bromination of phenol.

\[
\text{A} \quad \text{B} \quad \text{C} \quad \text{D} \quad \text{E}
\]

10. Choose the major product of the following reaction.

\[
\text{A} \quad \text{B} \quad \text{C} \quad \text{D} \quad \text{E}
\]
11. Choose the major product of the following Diels-Alder reaction.

![Diels-Alder reaction diagram]

12. Choose the order that has the following compounds correctly arranged with respect to increasing wavelength of their ultraviolet-visible light absorption.

![Order of compounds diagram]

**Short Answer Questions. 40 points.**

13. (10 pts) The diethylaluminum chloride catalyzed Diels-Alder reaction gives the following bicyclic compound.

(a) Give the structure of the Diels-Alder reactant in the above reaction.

(b) Give an explanation for how the catalyst accelerates this reaction. **The role of the lewis acid is remove electron density from the dienophile by cordinating to the oxygen atom of the carbonyl group. This will lower the LUMO of the dienophile causing it to be a better electron acceptor which will facilitate the HOMO-LUMO interaction.**
14. (10 pts) Below is the cycloaddition reaction of butadiene with the allyl cation. Because one of the reactants is a cation, one HOMO-LUMO combination would be predicted to play an important role in this reaction.

(a) On the answer sheet draw the HOMO and the LUMO molecular orbitals that would be predicted to play the most important role in the above reaction.

(b) Using the above HOMO-LUMO analysis state, with an explanation, whether or not the above reaction would be predicted to be favorable. The symmetry of the critical orbitals demonstrates there is a favorable interaction between the HOMO of the diene and LUMO of the propenyl cation. This is analogous to the Diels-Alder reaction. This reaction is predicted to be favorable.

15. Using the Diels-Alder reaction, propose a good synthesis of β-bisabolene from compounds containing five carbon atoms or less.

16. Using the curved arrow formalism show the bond making and bond breaking that occur in the following transformation.