Multiple Choice Questions: 60 points

1. Choose the major product of the following reaction.

   \[
   \begin{align*}
   \text{H-Br} & \quad 75 \, ^{\circ}\text{C} \\
   \text{H}_2\text{C} &= \text{CH}_2 \\
   \end{align*}
   \]

   (A) \quad (B) \quad (C)

   (D) \quad (E)

2. Choose the correct reactant that will lead to the following Diels-Alder product.

   \[
   \text{heat} \quad \rightarrow \quad + \text{enantiomer}
   \]

   (A) \quad (B) \quad (C)

   (D) \quad (E)
3. Choose the order that has the following carbanions correctly arranged with respect to increasing stability.

\[ \text{1} \quad \text{2} \quad \text{3} \]

- (A) 1 → 2 → 3 increasing stability
- (B) 2 → 3 → 1 increasing stability
- (C) 2 → 1 → 3 increasing stability
- (D) 3 → 1 → 2 increasing stability
- (E) 3 → 2 → 1 increasing stability

4. Select the compound(s) that is(are) aromatic.

I  II  III  IV

- (A) I only
- (B) II and IV
- (C) I, II and IV
- (D) I, III and IV
- (E) All of them

5. This Friedel-Crafts alkylation will give a mixture of products. Choose the major product.

- (A)
- (B)
- (C)
- (D)
- (E)
6. Select the major product from the following reaction sequence.

\[
\text{H-Cl} \quad \text{NBS} \\
-78^\circ \text{C}
\]

(A) \hspace{2cm} (B) \hspace{2cm} (C)

(D) \hspace{2cm} (E)

7. Select the major product of the following reaction.

\[
\text{HNO}_3 \quad \text{H}_2\text{SO}_4
\]

(A) \hspace{2cm} (B) \hspace{2cm} (C)

(D) \hspace{2cm} (E)
8. Select the reaction that will have the lowest activation energy.

(A) \[
\begin{align*}
\text{H}_3\text{CO} & \quad + \\
\text{heat} & \quad \rightarrow
\end{align*}
\]
(B) \[
\begin{align*}
\text{F} & \quad \text{heat} \\
\text{heat} & \quad \rightarrow
\end{align*}
\]
(C) \[
\begin{align*}
\text{H}_3\text{C} & \quad \text{heat} \\
\text{heat} & \quad \rightarrow
\end{align*}
\]

9. Select the statement that is not true concerning the following compounds.

(A) Compound 1 has the shortest \( \lambda_{\text{max}} \) absorption band.
(B) The HOMO of the \( \pi \) system of compound 2 contains two nodal planes.
(C) Compound 3 contains 10 \( \pi \) molecular orbitals.
(D) The LUMO of compound 1 is a symmetric \( \pi \) molecular orbital.
(E) The LUMO of the \( \pi \) system of compound 3 contains 4 nodal planes.

10. Cyclopentadiene is not stable for long at room temperature. It reacts with itself to form a dimer. What is the structure of that dimer?

2 \[
\begin{align*}
\text{heat} & \quad \rightarrow
\end{align*}
\]

(A) \[
\begin{align*}
\text{(A)} & \\
\text{(B)} & \\
\text{(C)} & \\
\text{(D)} & \\
\text{(E)} & 
\end{align*}
\]
11. Molecular orbital theory can explain why cyclopentadienyl cation is especially unstable. Select the statement that is true concerning the \( \pi \) molecular orbital system of cyclopentadienyl cation.

![Cyclopentadienyl Cation](Image)

(A) The two highest energy electrons are unpaired, residing in degenerate bonding molecular orbitals.
(B) The two highest energy electrons are paired in an antibonding molecular orbital.
(C) All of the electrons are paired, but the bonding shell is not filled.
(D) The two highest energy electrons reside in a nonbonding molecular orbital.
(E) The two highest energy electrons are unpaired, residing in degenerate antibonding molecular orbitals.

12. Select the most efficient reaction pathway to produce 1-bromo-4-ethylbenzene from benzene.

![Reaction Pathway](Image)

(A) \( \text{Br}_2 \xrightarrow{\text{FeBr}_3} \text{Cl} \) (B) \( \text{Cl} \xrightarrow{\text{AlCl}_3} \text{Zn (Hg)} \xrightarrow{\text{Br}_2} \) (C) \( \text{Cl} \xrightarrow{\text{AlCl}_3} \text{Br}_2 \) (D) \( \text{Cl} \xrightarrow{\text{AlCl}_3} \) (E) \( \text{Br}_2 \xrightarrow{\text{FeBr}_3} \text{Cl} \xrightarrow{\text{AlCl}_3} \text{Zn (Hg)} \xrightarrow{\text{HCl}} \)
Short Answer Questions: 40 points

13. Predict the major product for each reaction/reaction sequence. Place your answer in the given box (indicate stereochemistry where appropriate, using wedges and dashes). 12 pts

(a) \( \text{H}_3\text{CO} + \text{NO}_2^- \xrightarrow{\text{heat}} \) + enantiomer

(b) \( \text{CH}_3\text{C} - \text{CH}_3 \xrightarrow{1. \text{KMnO}_4, \text{OH}, \text{heat}} \) \( \text{SO}_3 \xrightarrow{2. \text{H}_3\text{O}^+} \) \( \text{H}_2\text{SO}_4 \text{conc.} \)

(c) \( \text{Br}_2 \xrightarrow{\text{FeBr}_3} \) \( \text{Cl}_2 \xrightarrow{\text{SOCl}_2} \) \( \text{AlCl}_3 \)

14. Propose a synthesis of the following compound starting from benzene and using any compound(s) containing 3 carbons or less. 8 pts

\[
\begin{array}{c}
\text{O} \\
\text{O} \\
\end{array}
\]
15. Propose a synthesis of the following compound starting from benzene and using any reagents. 10 pts

\[ \text{Cl} \quad \text{NO}_2 \]

16. Electrophilic aromatic substitution is not limited to benzene rings. Below is the bromination of pyrrole. Two products are possible, but only one of them is the major product. 10 pts

\[ \text{H} \quad \text{N} \quad \text{Br} \quad \xrightarrow{\text{Br}_2, \text{FeBr}_3} \quad \text{H} \quad \text{N} \quad \text{Br} \quad + \quad \text{H} \quad \text{N} \quad \text{Br} \]

a) Using the curved arrow formalism, draw a mechanism that leads to the major product, showing all the bond breaking and bond making steps.

b) Circle the major product, and explain your choice using resonance structures. Draw all the good contributing structures for the intermediate that leads to each product. You will not receive any partial credit for simply choosing the correct major product. 10 pts