1. Determine which of the following are aromatic or anti-aromatic.

2. Which one in the following pair is more acidic? Hint: remove a proton from the $sp^3$ carbon in each structure and count electrons.

3. Which compound listed below generates a carbocation more readily?
4. On which nitrogen atom's will protonation occur most readily?

\[
\begin{array}{c}
\text{N} \\
\text{H}
\end{array}
\quad
\begin{array}{c}
\text{N} \\
\text{H}
\end{array}
\]

5. Consider the following annulenes. Each will have two proton resonance signals.

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array}
\quad
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array}
\]

Identify the above annulene in which its inner hydrogens will appear upfield from TMS and the one in which its outer hydrogens will appear upfield from TMS. Briefly explain your answer.
6. Write an energy diagram of the molecular orbitals of cyclopropenium cation

\[ \text{Diagram of molecular orbitals} \]

a. Is this cation aromatic or anti-aromatic? Explain briefly

5. Would the cyclopropenium anion be aromatic or anti-aromatic? Explain briefly.

7. Name the following compounds using either common or IUPAC names

- ![Compound 1](image1)
- ![Compound 2](image2)
- ![Compound 3](image3)
- ![Compound 4](image4)
- ![Compound 5](image5)
8. Give the mechanism, all steps, for the bromination of acetanilide (PhNHCOCH₃) to give p-bromoacetanilide. I would suggest you use the "English" method by using the lone pair electrons on the nitrogen atom to direct the nitration at the para position. Recall that this leads directly to the particularly stable resonance structure. Indicate which step is rate determining.

   step 1 - generation of electrophile

   step 2 - generation of sigma complex

   step 3 regeneration of aromatic ring

9. Identify the electrophilic reagent in the following reactions

   a. nitration
   b. Friedel-Craft acylation
   c. Chlorosulfonation

10. List the following groups in order of decreasing activation in electrophilic aromatic substitution.

    OH   NH₂   Cl   NO₂
    A     B     C     D
d. anisole (phenyl methyl ether) \[ \text{HI} \xrightarrow{\text{heat}} \]

e. cyclopentene + NBS \[ \text{ROOR} \xrightarrow{} \]

\[ f. \]

\[ \text{H}^+ \text{MeOH} \]

\[ 1. \text{PhLi} \]

\[ 2. \text{H}^+ \]

\[ g. \]

\[ + \]

\[ h. \]

\[ \text{CO}_2\text{Et} \]

\[ \text{CO}_2\text{Et} \]

\[ \text{CO}_2\text{Et} \]
Deduce the diene and dienophile that reacted to produce the cyclic compound shown below.

Consider the reaction shown below.

Two possible allyl cations can form. Write the pertinent resonance structures for each possible allyl cation. (Don't forget that the oxygen atom has lone pairs of electrons!!)

On the basis of resonance delocation, circle the more stable cation and show which carbon is attacked by Br\(^{-}\) to give the thermodynamically stable product.
Write the MO diagram for the pentadienyl cation (CH$_2$=CH-CH=CH-CH$_2^+$.  
INDICATE CLEARLY: A. LUMO, B. HOMO, c. non-Bonding MO, d. Number of nodes in each MO, e. symmetry of each MO with respect to plane perpendicular to the plane of the paper, e. The sign of the upper lobe of the first and last carbon in each MO.

Using the frontier orbital method (LUMO and HOMO interactions) predict whether the thermal or photochemical cycloaddition reactions shown below would be "allowed" (i.e. concerted). You must clearly identify the HOMO and LUMO interacting MOs and sign of the upper lobes of the interacting $p$-orbitals.

- 9-membered cation ring
- 9-membered cation ring