1) Some chemical species are not accurately described by a single Lewis Structure. Draw a Lewis structure of an example of such a….. (4pts)

a) Neutral Compound  
b) Carbanion  

c) Carbocation  
d) Radical

2) Indicate which of the following molecules are aromatic, non-aromatic or anti-aromatic. (Assume all the molecules are planar). (15pts)
3) Predict the products in the following reactions, paying attention to regio/stereochemistry where applicable. (21pts)

![Reaction 1](image1)

![Reaction 2](image2)

![Reaction 3](image3)

![Reaction 4](image4)

![Reaction 5](image5)

![Reaction 6](image6)
4) In each pair, circle the **stronger base**. (6pts)

- benzene or pyridine
- pyrazole or pyrrole
5) Explain briefly why each of these five reactions do not work (15 pts).

\[
\begin{align*}
\text{NO}_2 + \text{excess NaOH} \rightarrow \text{NO REACTION} \\
\text{CH}_3\text{Cl, AlCl}_3 + \text{heat} \rightarrow \text{NO REACTION} \\
\text{Br}_2 + \text{excess H-Br} \rightarrow \text{NO REACTION} \\
\text{NO REACTION} \\
\text{CH}_3\text{Cl, AlCl}_3 + \text{NO}_2 \rightarrow \text{NO REACTION} \\
\text{Br}_2 + \text{excess NaOH} \rightarrow \text{NO REACTION}
\end{align*}
\]
6) Give reagents for the following multistep transformations. 
(4+3+3+5=15pts)

in a 1:1 ratio
7) The addition of (1 equivalent of) Cl$_2$ to 1,3-cyclopentadiene generates a mixture of products.

\[ \text{Cl-Cl} \rightarrow \text{Cl} \text{-} \text{Cl} \text{ and } \text{Cl} \text{-} \text{Cl} \]

a) Indicate which is the 1,2 and the 1,4 addition product.

b) Draw the mechanism showing how both products are formed. (9pts)
8) Devise synthetic schemes to generate the products from the starting material; bearing in mind more than one step is obviously required. (15pts)

a) \[
\begin{align*}
\text{CH}_2\text{CH}_3 & \quad \text{CH}_2\text{CH}_3 \\
\end{align*}
\]

b) \[
\begin{align*}
\text{CH}_3 & \quad \text{CO}_2\text{H} \\
\text{Br} & \quad \text{SO}_3\text{H} \\
\end{align*}
\]

c) \[
\begin{align*}
\text{OH} & \quad \text{OCH}_2\text{CH}_2\text{CH}_3 \\
\text{NO}_2 & \\
\end{align*}
\]
1) Some chemical species are not accurately described by a single Lewis Structure. Draw a Lewis structure of an example of such a..... (4pts)

   a) Neutral Compound
   b) Carbanion

   c) Carbocation
   d) Radical

2) Indicate which of the following molecules are aromatic, non-aromatic or anti-aromatic. (Assume all the molecules are planar). (15pts)
3) Predict the products in the following reactions, paying attention to regio/stereochemistry where applicable. (21 pts)
4) In each pair, circle the **stronger base**. (6pts)
5) Explain briefly why each of these five reactions do not work (15 pts).

\[ \text{NO REACTION} \]

**Thermal [2+2] cycloadditions are forbidden according to the Woodward/Hoffmann rules. The orbitals involved in this pericyclic reaction (Homo & Lumo) do not match up.**

- **excess H-Br**

**NO REACTION**

**Phenyl esters are not cleaved by acid since the aromatic ring blocks the nucleophile preventing S_{N}2 displacement. Also S_{N}1 reaction is unlikely since the required cation would not likely form.**

- **Br_{2}**

**NO REACTION**

**Bromine is not a strong enough electrophile to react with an aromatic ring system of benzene. The addition of a Lewis acid (e.g. FeBr₃) would convert the Br₂ to Br⁻⁺Br⁻FeBr₅ making it sufficiently electrophilic.**

- **NO₂**

**NO REACTION**

**Friedel-Craft reactions do not work on strongly deactivated aromatics. The Nitro group is strongly electron withdrawing and thus a powerful deactivator for E.A.S. reactions.**

- **excess NaOH**

**NO REACTION**

**NaOH is a basic and nucleophilic reagent. For eliminations or substitutions to occur with NaOH, a leaving group is required.**

**Benzene only has hydrogen substituents (no L.G.) so no reaction occurs.**
6) Give reagents for the following multistep transformations.

(4+3+3+5=15pts)

![Chemical structures and reactions](image)

- **First transformation**:
  - 1. $\text{CH}_3\text{Cl}, \text{AlCl}_3$
  - 2. $\text{CH}_3\text{Cl}, \text{AlCl}_3$
  - 3. $\text{KmNO}_4, \text{OH}^-, \text{H}_2\text{O}

- **Second transformation**:
  - 1. $\text{HNO}_3, \text{H}_2\text{SO}_4$
  - 2. $\text{Br}_2, \text{FeBr}_3$

- **Third transformation**:
  - 1. $\text{CH}_3\text{Cl}, \text{AlCl}_3$
  - 2. $\text{Cl}_2, \text{AlCl}_3$
  - 3. $\text{NaNH}_2$ (2 equiv)

- **Final product**:
  - in a 1:1 ratio

Sp08org2e1
7) The addition of (1 equivalent of) Cl₂ to 1,3-cyclopentadiene generates a mixture of products.

a) Indicate which is the 1,2 and the 1,4 addition product.

b) Draw the mechanism showing how both products are formed. (9pts)
8) Devise synthetic schemes to generate the products from the starting material; bearing in mind more than one step is obviously required. (15pts)

a) 

\[
\text{CH}_2\text{CH}_3 \quad \text{Cl}
\]

- 1. \( \text{CH}_3\text{C}-\text{Cl}, \text{AlCl}_3 \)
- 2. \( \text{CH}_2, \text{AlCl}_3 \)
- 3. \( \text{Zn(H}_2\text{)}, \text{HCl} \)

b) 

\[
\text{CO}_2\text{H} \quad \text{Br} \quad \text{SO}_3\text{H}
\]

- 1. \( \text{SO}_3, \text{H}_2\text{SO}_4 \)
- 2. \( \text{Br}_2, \text{FeBr}_3 \)
- 3. \( \text{KMnO}_4, \text{OH}, \text{Th, H}^+ \)

c) 

\[
\text{OH} \quad \text{OCH}_2\text{CH}_2\text{CH}_3
\]

- 1. \( \text{HNO}_3, \text{H}_2\text{SO}_4 \)
- 2. \( \text{NaOH, CH}_3\text{CH}_2\text{CH}_2\text{-Br} \)