1) (8pts) For the following compound, determine the number of:

a) carbon atoms
b) hydrogen atoms
c) π bonds
d) halogen atoms
e) sp² hybridized carbons
f) Nitrogen atoms
g) sp³ hybridized carbons
h) lone pairs (non bonding pairs) of electrons

2) Is the above structure AROMATIC, or ANTI-AROMATIC, or NON-AROMATIC? (2pts)

3) Which is the most basic atom in the above molecule? (2pts)
4) (2pts) a) What are resonance structures?

b) (2pts) What are tautomers?

c) (2pts) What is a Nucleophile?

d) (2pts) What is Occam’s Razor?
5) (10pts) Draw in the arrows for these resonance structures (as they convert from left to right).

(a) 

(b) 

(c) 

6) (3pts) Indicate whether A, B or C is the correct way to mechanistically illustrate the deprotonation of Ethanol:

A) \[ \text{CH}_3\text{CH}_2\text{O}^- \text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{O}^- + \text{H}_2\text{O} \]

B) \[ \text{CH}_3\text{CH}_2\text{O}^- \text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{O}^- + \text{H}_2\text{O} \]

C) \[ \text{CH}_3\text{CH}_2\text{O}^- \text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{O}^- + \text{H}_2\text{O} \]
7) (8pts) Circle the more stable species in each pair.

(a) \( \text{OH}^{-} \) or \( \text{NH}_{2}^{-} \)

(b) \( \text{O}^{-} \) or \( \text{O}^{-} \)

(c) \( \text{F}^{-} \text{OH} \text{NO}_{2}^{-} \) or \( \text{F}^{-} \text{OH} \text{NH}_{2} \)

(d) \( \text{O}^{-} \) or \( \text{OH}^{-} \)

8) (2pts) Describe briefly how can you experimentally prove a mechanism is correct?
9) (17pts) For the following transformation which involves a resonance stabilized anion doing a Michael Addition to an \(\alpha, \beta\)-unsaturated ketone:

\[
\begin{align*}
\text{\(\alpha, \beta\)-unsaturated ketone} & \quad + \quad \text{alkene} & \quad \xrightarrow{\text{NaOCH\textsubscript{3}}} & \quad \text{product}
\end{align*}
\]

i) (4pts) Label the \(\alpha\) and \(\beta\) carbons in the \(\alpha, \beta\)-unsaturated ketone, and also indicate where they end up in the product.

ii) (2pts) Using the ionic form of the Sodium Methoxide, write a mechanism showing the formation of the resonance stabilized anion below.

iii) (2pts) Methanol is the solvent for this reaction, is it:

- Polar or Non-Polar?
- Protic or Aprotic?

iv) (2pts) is this reaction performed under acidic, basic, or neutral reaction conditions?
v) (7pts) Draw in the curly arrows which describe the mechanism of this reaction:
In this section there are THREE questions, (A) – (C), you must answer only 2.

Each is worth 20 points.
A) (20pts) Write the mechanism for the following transformation.

\[
\begin{align*}
\text{N} & \quad \text{Cl} \\
\text{O} & \quad \text{O} \\
\text{Cl} & \quad \text{NaOCH}_3 \\
\text{O} & \quad \text{CO}_2\text{CH}_3 \\
\end{align*}
\]

(HINTS
i) Note the Carbon labeling scheme.

\[
\begin{align*}
\text{N} & \quad \text{Cl} \\
\text{O} & \quad \text{O} \\
\text{Cl} & \quad \text{NaOCH}_3 \\
\text{O} & \quad \text{CO}_2\text{CH}_3 \\
\end{align*}
\]

ii) Pay attention to the reaction conditions.

iii) The reaction starts with the Methoxide performing nucleophilic acyl substitution on the cyclic ester.

iv) The last step is the displacement of the chlorine).
B) (20pts) Write the mechanism for this reaction.

\[
\text{N} \begin{array}{c} \text{Br} \\ \text{N} \end{array} \xrightarrow{\text{NaOH}} \text{N} \begin{array}{c} \text{OH} \\ \text{N} \end{array}
\]

(HINT: It involves a rearrangement).
C) (20pts) The following is a base promoted cyclization. Write the mechanism for this reaction.

\[
\begin{array}{c}
\text{O} & \text{S} & \text{O} & \text{H} \\
\end{array}
\xrightarrow{\text{dilute NaOH}}
\begin{array}{c}
\text{H}_2\text{O} \\
\end{array}
\xrightarrow{}
\begin{array}{c}
\text{O} \\
\end{array}
\]

(HINTS:

i) The reaction starts with deprotonation of the ketone, generating a resonance stabilized anion.

ii) That anion reacts with the aldehyde.

iii) The final step is base catalyzed dehydration.)
1) (8pts) For the following compound, determine the number of:

![Chemical Structure]

a) carbon atoms 13
b) hydrogen atoms 15
c) π bonds 2
d) halogen atoms 5
e) sp² hybridized carbons 4
f) Nitrogen atoms 2
g) sp³ hybridized carbons 9
h) lone pairs (non bonding pairs) of electrons 17

2) Is the above structure AROMATIC, or ANTI-AROMATIC, or NON-AROMATIC? (2pts) AROMATIC

3) Which is the most basic atom in the above molecule? (2pts) Top N
4) (2pts) a) What are resonance structures?

Species that only differ in their placement of electron density.

b) (2pts) What are tautomers?

Species that are isomers that are in equilibrium with each other (usually through the relocation of readily exchangeable atoms, e.g., acidic hydrogens).

c) (2pts) What is a Nucleophile?

A two electron donor.

d) (2pts) What is Occam's Razor?

The simplest answer is usually the correct answer.
5) (10pts) Draw in the arrows for these resonance structures (as they convert from left to right).

(a)

(b)

(c)

6) (3pts) Indicate whether A, B or C is the correct way to mechanistically illustrate the deprotonation of Ethanol:

A) $\text{CH}_3\text{CH}_2\text{O}^-\text{H} \quad \text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{O}^- \quad \text{H}_2\text{O} \quad \times$

B) $\text{CH}_3\text{CH}_2\text{O}^-\text{H} \quad \text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{O}^- \quad \text{H}_2\text{O} \quad \checkmark \quad \text{CORRECT}$

C) $\text{CH}_3\text{CH}_2\text{O}^-\text{H} \quad \text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{O}^- \quad \text{H}_2\text{O} \quad \times$
7) (8pts) Circle the more stable species in each pair.

(a) \( \text{OH}^- \) or \( \text{NH}_2^- \)

(b) \( \text{phenol}^- \) or \( \text{cyclohexanol}^- \)

(c) \( \text{fluorophenol}^- \) or \( \text{aminoaromatic}^- \)

(d) \( \text{fluorobenzoate}^- \) or \( \text{benzoate}^- \)

8) (2pts) Describe briefly how can you experimentally prove a mechanism is correct?

You cannot prove a mechanism, only disprove an incorrect mechanism.
9) (17pts) For the following transformation which involves a resonance stabilized anion doing a Michael Addition to an $\alpha$, $\beta$-unsaturated ketone:

\[
\begin{align*}
\text{Ko} & + \beta^\alpha \text{C} 
\end{align*}
\]

\[
\begin{array}{c}
\text{NaOCH}_3 \\
\text{CH}_3\text{OH}
\end{array}
\]

\[
\rightarrow
\begin{align*}
\text{Ko} & + \beta^\alpha \text{C}
\end{align*}
\]

i) (4pts) Label the $\alpha$ and $\beta$ carbons in the $\alpha$, $\beta$-unsaturated ketone, and also indicate where they end up in the product.

ii) (2pts) Using the ionic form of the Sodium Methoxide, write a mechanism showing the formation of the resonance stabilized anion below.

\[
\begin{align*}
\text{Ko} & + \beta^\alpha \text{C} 
\end{align*}
\]

\[
\begin{array}{c}
\text{NaOCH}_3 \\
\text{CH}_3\text{OH}
\end{array}
\]

\[
\rightarrow
\begin{align*}
\text{Ko} & + \beta^\alpha \text{C}
\end{align*}
\]

iii) (2pts) Methanol is the solvent for this reaction, is it:

- Polar or Non-Polar? Polar
- Protic or Aprotic? Protic

iv) (2pts) Is this reaction performed under acidic, basic, or neutral reaction conditions? Basic
v) (7pts) Draw in the curly arrows which describe the mechanism of this reaction:
In this section there are THREE questions, (A) – (C), you must answer only 2.

Each is worth 20 points.
A) (20pts) Write the mechanism for the following transformation.

(HINTS)
i) Note the Carbon labeling scheme.

ii) Pay attention to the reaction conditions.

iii) The reaction starts with the Methoxide performing nucleophilic acyl substitution on the cyclic ester.

iv) The last step is the displacement of the chlorine.

[Chemical structures and reactions shown]
B) (20pts) Write the mechanism for this reaction.

(HINT: It involves a rearrangement).
C) (20pts) The following is a base promoted cyclization. Write the mechanism for this reaction.

\[ \text{dilute NaOH} \]

\[ \text{H}_2\text{O} \]

(HINTS:

i) The reaction starts with deprotonation of the ketone, generating a resonance stabilized anion.

ii) That anion reacts with the aldehyde.

iii) The final step is base catalyzed dehydration.)