1) Provide one good scientific reason why you are taught about Molecular Orbital Theory.

Provide structures of two compounds or species whose bonding is not accurately described by a Lewis Structure. (4pts)

2) Indicate which of the following molecules are aromatic, non-aromatic or anti-aromatic. (Assume all the molecules are planar). (15pts)
3) Using the polygon rule, draw out and decide whether the following charged species are aromatic or anti-aromatic. (8pts)

- Cyclopentadienyl anion
- Cyclopropenyl cation
4) Predict the products in the following reactions (if you believe no reaction will occur, indicate this!), paying attention to regio/stereochemistry where applicable. (24pts)

\[
\begin{align*}
\text{NO}_2 & \quad \text{Cl}_2, \text{AlCl}_3 \\
\text{UV Light} & \\
\text{Excess HBr} & \\
\text{Heat} & \\
\text{Excess HI} & \\
\text{Heat} & \\
\end{align*}
\]
5) Imidazole, shown below is a $6\pi$ aromatic compound with two Nitrogen atoms.

Explain why one of the Nitrogen atoms is very much more basic than the other. (12pts)
6) Give reagents, conditions and intermediate A compounds for the following transformations. (3+3+4+4+4=18pts)
7) The addition of (1 equivalent of) Br₂ to 1,3-cyclopentadiene generates a mixture of products.

\[
\begin{array}{c}
\text{Cyclopentadiene} \\
\text{Br-Br} \\
\rightarrow
\end{array}
\begin{array}{c}
\text{Br} \\
\text{Br} \\
\text{Br} \\
\text{Br} \\
\text{Br}
\end{array}
\]

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

b) Draw the mechanism showing how both products are formed.

c) Indicate which product you think is more stable, and provide a justification for your choice. (2+5+2 = 9pts)
8) Devise synthetic schemes to generate the products from the starting material; bearing in mind more than one step is obviously required. (10pts)

a) 

\[
\begin{align*}
\text{CH}_3 & \quad \rightarrow \\ & \quad \text{NO}_2
\end{align*}
\]

b) 

\[
\begin{align*}
\text{CH}_2\text{CH}_3 & \quad \rightarrow \\ & \quad \text{Br}
\end{align*}
\]
*Bonus questions from the last lecture* (up to 10pts)

a) In an NMR experiment, what is the purpose of the large external magnetic field?

b) What do the radio waves do in an NMR experiment?

c) How many years ago was Dr. Roche’s mass spectrometer installed?

d) How many influential mentors did Dr. Roche talk about and show photos of?

e) What country or countries are they from?

f) State one thing you remember about those photographs.
Name: ANNIE BUDDY HONE

If you do not wish to have your graded exam placed outside my office please check here_______

1) Provide one good scientific reason why you are taught about Molecular Orbital Theory. It accurately describes delocalized π bonding; pericyclic "allowed" & "forbidden" reactions; aromaticity.

Provide structures of two compounds or species whose bonding is not accurately described by a Lewis Structure. (4pts)

![Structures of compounds](image)

2) Indicate which of the following molecules are aromatic, non-aromatic or anti-aromatic. (Assume all the molecules are planar). (15pts)

![Structures of molecules](image)
3) Using the polygon rule, draw out and decide whether the following charged species are aromatic or anti-aromatic. (8pts)

- (cyclopentadienyl anion)
- (cyclopropenyl cation)

There are 6π electrons

- Closed bonding shell = AROMATIC

There are 2π electrons

- Closed bonding shell = AROMATIC
4) Predict the products in the following reactions (if you believe no reaction will occur, indicate this!), paying attention to regio/stereochemistry where applicable. (24pts)
5) Imidazole, shown below is a $6\pi$ aromatic compound with two Nitrogen atoms.

![Imidazole structure]

Explain why one of the Nitrogen atoms is very much more basic than the other. (12pts)

When this $\text{N}$ is protonated, it generates a non-aromatic species. The loss of aromaticity is energetically unfavourable. Therefore this reaction will not occur. This $\text{N}$ is not basic.

When this $\text{N}$ is protonated, it generates an aromatic species. In this reaction the desired aromaticity is maintained. Therefore this $\text{N}$ will get protonated easily. This $\text{N}$ is basic.
6) Give reagents, conditions and intermediate A compounds for the following transformations. (3+3+4+4+4=18pts)
7) The addition of (1 equivalent of) Br₂ 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.

c) Indicate which product you think is more stable, and provide a justification for your choice. (2+5+2 = 9pts)

Both cyclohexene have equally substituted double bonds & therefore are of very similar stability.

The 1,4 product has the Br's further away from each other, & has the least steric hindrance from the very large Bronns.
8) Devise synthetic schemes to generate the products from the starting material; bearing in mind more than one step is obviously required. (10pts)

a)\[
\begin{align*}
\text{CH}_3 & \quad \rightarrow \\
& \quad \text{NO}_2 \\
& \quad \text{CO}_2\text{H} \\
& \quad \text{Br}
\end{align*}
\]

\[
\text{i)} \quad \text{HNO}_3, \text{H}_2\text{SO}_4 \\
\text{ii)} \quad \text{Br}_2, \text{FeBr}_3 \\
\text{iii)} \quad \text{KMnO}_4, \text{NaOH}, \text{then} \text{HCl}.
\]

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

\[
\text{i)} \quad \text{CH}_3\text{C}^\text{\text{\textdegree}}\text{Cl, AlCl}_3 \\
\text{ii)} \quad \text{Br}_2, \text{FeBr}_3 \\
\text{iii)} \quad \text{Zn (Hg), HCl}.
\]