PRINT your name legibly on the line below.

Key

PRINT your student id number on the line below.
Place your student identification on your desk. A proctor will come around to check your ID. **Put your name and number on your test?**

It is critically important that your answers be written in a clear, unambiguous manner. Solutions in which your intentions are unclear may not receive credit. **SHOW YOUR WORK!**

<table>
<thead>
<tr>
<th>Problem Number</th>
<th>Points possible</th>
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**Total** 200
1. (15 pts.) See the figure above. Circle the molecules with aromatic electronic configuration.

2. (10 pts.) Very briefly make a comparison between the transition states of the Diels-Alder reaction and of hydride shifts in carbocation rearrangements. What fundamental aspect do they share? Why are they both so relatively fast?

2. They both obey the 4N+2 rule
Both are aromatic.
3. (10 pts.) Predict the product of the following Diels-Alder reaction. There is stereochemistry and regiochemistry involved. For a bare bones Diels-Alder reaction see problem 2.

![Diels-Alder reaction](attachment:image.png)

Problem 3

4. (10 pts.) What structural/ electronic feature(s) is (are) making the reaction in 3 go from left to right? In other words, why is the reaction exothermic in problems 2 and 3?

\[ \text{T to } \text{ bond conversion.} \]

5. (10 pts.) Devise a synthesis of the following molecule.

![Synthesis reaction](attachment:image.png)

Problem 5
6. (10 pts.) Which diene participates \textbf{fastest} in the Diels-Alder reaction? \(\text{a}\) Which diene participates \textbf{slowest} in the Diels-Alder reaction? \(\text{c}\) You must get both right for any credit.

\begin{center}
a \quad b \\
\quad c \quad d
\end{center}

Problem 6

7. (10 pts.) Predict the product of the following reaction.

\begin{center}
\text{NBS} \quad \text{light}
\end{center}

Problem 7

8. (10 pts.) Circle the molecule that absorbs light at the lowest energy? (The lowest energy photons, the longest wavelength). For partial credit you can offer a brief explanation.

\begin{center}
\text{most conjugated. least energetic separation between HOMO & LUMO.}
\end{center}
9. (10 pts) Put the product at the right of the arrow above.

\[ \text{Problem 9.} \]

\[ \text{hexane (solvent)} \]

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

\[ \text{small amount} \]

(10 pts) Put the product at the right of the arrow above. The reaction conditions are such that methylstyrene (material at left) is very concentrated. The reaction will result in polymerization. Draw a few units of the polymer.
11. (10 pts.) Draw an E2 product of the molecule below. There is stereochemistry to consider. You will not get full credit unless you include stereochemistry in your answer.

Problem 11.

12. (10 pts.) In the molecule in problem 11, what is the absolute stereochemistry of the carbon atom attached to Br, R or S? \( \text{R} \). What is the absolute stereochemistry of the other stereogenic atom? \( \text{S} \).

13. (10 pts.) Complete the figure below to show a diastereomer of the reactant in problem 11.

Problem 13.
14. Count the $^{13}\text{C}$ NMR signals in the following molecules.

a. (5 pts.)

\[
\begin{array}{c}
\text{O} \\
\text{O} \\
\text{O} \\
\text{O} \\
\text{O} \\
\text{O} \\
\end{array}
\]

1

b. (5 pts.)

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

2

15. (10 pts.) Name the following molecule.

\[
\begin{array}{c}
\text{Br} \\
\text{F} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{H}_3 \\
\end{array}
\]

Problem 15

1-bromo-3-fluoro-5-methyl benzene.

3-bromo-5-fluoro toluene

16. (10 pts.) Put the product at the right of the arrow below.

\[
\begin{array}{c}
\text{CH}_3 \text{COOH} \\
\text{C} \\
\text{O} \\
\text{OH} \\
\end{array}
\] + \[
\begin{array}{c}
\text{C} \\
\text{C} \\
\end{array}
\] \text{hexane (solvent)}

\[
\begin{array}{c}
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\end{array}
\]

Problem 16
17. (10 pts.) Circle the protons that are most acidic.

![Chemical Structure](image)

Problem 17

18. (Think)

a. (8 pts.) How are carbocations, carbenes and radicals alike? What makes them all unstable?

They are all electron-poor. They lack a complete octet at carbon.

(7 pts.) So I know what you are talking about, draw Lewis Structures of methyl radical, methyl cation and methylene. Label the structures. Include all atoms as letter symbols, include all electrons and charges.

![Lewis Structures](image)

19. (10 pts.) On the back of this page draw a reaction energy diagram of an exothermic S_N1 (unimolecular) reaction (this reaction has one intermediate).
20.

[Diagram of an energy profile with reactant and product labeled. The reactant is lower in energy than the product.]