# CHE 230-002 Organic Chemistry Exam 2, 2011

Name: **Key**  
Student ID No.:  

**Before you begin this exam:** First: You are allowed to have a simple model set at your seat. Please put away all other materials. Second: Place your student identification on your desk. A proctor will come around to check everyone’s ID. Third: Read through the entire exam. Your goal, as always, is to score as many points as possible. Do not waste time on problems that you can’t do if there are others that look easy. Fourth: READ EACH QUESTION CAREFULLY. Be sure you answer the question that is asked. Fifth: Once the start time is announced, you will have one hour to complete this exam. There will be no extensions, so budget your time carefully.

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1. (15 points) Label the following Newman projections as **staggered** or **eclipsed** and, where appropriate, **anti** or **gauche**. Indicate which conformation is **highest** in energy and which conformation is **lowest** in energy.

[Diagrams of Newman projections]

- **eclipsed**
- **staggered**
- **anti**
- **highest** energy
- **lowest** energy
- **gauche**

2. (15 points) **Draw the resonance hybrid** for each of the structures below. **Circle the sp²-hybridized atoms** on the structures provided (not in your hybrid). Do not show any implied C or H atoms.

[Diagrams of molecular structures]
3. (10 points) Label each double bond in the molecule below as E or Z.

4. (15 points) Draw the following molecules in their most stable chair conformation. Be sure that the direction of the bonds (axial or equatorial) is drawn in a way where it is easy to determine axial/equatorial positions from your drawing. You may show implied H atoms and CH₃ groups, although it is not necessary if you wish to be more concise.
5. (20 points) Assign the relationship between each pair of molecules (constitutional isomers, enantiomers, diastereomers, or the same).

\[
\begin{align*}
\text{diastereomers} & \quad \text{same} \\
\text{enantiomers} & \quad \text{same}
\end{align*}
\]

6. (20 points) For each of the structures below, assign whether the molecule is aromatic, antiaromatic, or non-aromatic.

\[
\begin{align*}
\text{anti} & \quad \text{aromatic} & \quad \text{non} & \quad \text{aromatic} & \quad \text{aromatic} & \quad \text{non} & \quad \text{aromatic} & \quad \text{aromatic}
\end{align*}
\]

7. (10 points) Unlike most hydrocarbon molecules (those consisting only of H and C), the molecule drawn below has a significant dipole. Draw an arrow showing the net dipole of this molecule. Concisely describe the reason why this molecule has a significant dipole, and draw the second best resonance structure of this molecule to support your answer.

\[
\begin{align*}
\text{This resonance form makes both rings aromatic by Hückel's rule}
\end{align*}
\]
8. (5 points) Circle the polyene that absorbs the longest wavelength (lowest energy) of UV-visible light.

![Polyene structures]

9. (20 points) Draw the skeletal structure of the major product of each of the following Diels–Alder reactions, including stereochemistry where appropriate. Note: there may be more than one major product formed in equal ratios to a stereoisomer. If more than one major product forms in equal ratios to a stereoisomer, draw only one stereoisomer (in this case, either stereoisomer is acceptable). You may show implied H atoms and may use labels such as CH₃, OCH₃, and CN in your products. However, if you choose to show an implied H on a C atom, you must show all implied H atoms on that C atom. Do not show lone pair electrons.

![Chemical reactions and structures]
10. (10 points) Give the skeletal structures for the two sets of starting materials that can be used to prepare the following compound by the Diels-Alder reaction. Identify the preferred pair of starting materials in the space below. Do not show implied H or C atoms. Do not show lone pair electrons.

Diels-Alder product:

Starting Materials Set 1

Starting Materials Set 2

Preferred: 1 or 2?

11. (15 points) Draw the skeletal structure of the major product of each reaction. Do not show any implied C or H atoms. Do not show lone pair electrons. Only one answer should be provided for each reaction. Although stereogenic products form in these reactions, do not show wedges and dashes in any structure.
12. (20 points) Draw the reaction mechanism and cationic intermediates leading to both the major kinetic product and the major thermodynamic product for the reaction of 1,3-butadiene (shown below) with one equivalent of HBr. Label the more stable cationic intermediate. Label the kinetic product and the thermodynamic product. For each C atom, you may show either all H atoms or no H atoms. Although the products may contain stereogenic C atoms, do not show any wedges or dashes in your products.

Kinetic:

Thermodynamic:
13. (15 points) The mass spectrum of an unknown compound has a molecular ion with \( m/z = 73 \). The mass spectrum shows an M+1 peak of 4.78\% the intensity of the molecular ion peak, and no appreciable M+2 or higher peaks. The molecule has the following IR spectrum.

![](image)

a) Propose a viable molecular formula for this compound. Note: A viable formula corresponds to at least one stable, neutral compound.

\[ \text{C}_4 \text{H}_{11} \text{N} \]

b) Draw a structure for the compound that is consistent with all of the spectral data given above.

\[ \text{NH}_2 \text{ or } \text{XNH}_2 \text{ and other variations accepted} \]

c) What bond stretch in your proposed structure is responsible for the IR absorption at ca. 3360 cm\(^{-1}\)?

\[ \text{N-H} \]
14. (10 points) When analyzing an unknown organic liquid, the mass spectrum shows a molecular ion with $m/z = 200$. There is an M+1 peak at 2.2% intensity of the molecular ion peak, an M+2 peak at twice the intensity as the molecular ion peak, and an M+4 peak with the same intensity as the molecular ion peak. What is the only reasonable chemical formula for this compound? Note: Your formula should correspond to a neutral compound.

$C_2H_4OBr_2$