Name ______________________
Signature ___________________ 
Student ID Number ____________

Dr. Badger
Chemistry 325
October 2, 2009

DO NOT OPEN THE EXAM UNTIL INSTRUCTED

Exam 1

Directions:

Please check the exam to be sure there are 9 non-blank pages including the title page. Read all questions and directions carefully before entering answers.

GOOD LUCK
Multiple Choice (30 points – 3 points per question)

Record the choice that best completes the statement or answers the question on the scantron sheet.

1. What color is your exam?
   a. yellow
   b. blue
   c. green

2. Which of the following species possesses a formal charge?
   a. BH$_3$
   b. BH
   c. CCl$_4$
   d. H$_2$S

3. Which of the following is a polar covalent bond?
   a. Na–F
   b. C–H
   c. C–O
   d. Cl–Cl

4. Which of the following cycloalkanes has the most ring strain?
   a. cyclopropane
   b. cyclobutane
   c. cyclopentane
   d. cyclohexane

5. Which of the following structures represents \textit{trans}-1,3-dimethylcyclohexane?

   a. 1
   b. 2
   c. 3
   d. 4

6. Which of the following molecules has a molecular dipole?

   a. 1
   b. 2
   c. 3
   d. 4
7. Which of the following compounds is/are chiral?

![Chemical structures]

a. only 1  

b. only 1 and 2  

c. only 2 and 3  

d. 1, 2 and 3

8. Which of the following have the S configuration?

![Chemical structures]

a. only 1  

b. only 2  

c. only 1 and 2  

d. 1, 2 and 3

9. Which of the following compounds is a meso compound?

a. (2R,3R)-dibromobutane  

b. (2R,3S)-dibromobutane  

c. (2R,3S)-3-bromo-2-butanol  

d. (2R,3R)-3-bromo-2-butanol

10. Which of the following is the strongest acid?

a. CH₃CH₃  

b. CH₃NH₂  

c. CH₂OH  

d. CH₃F

11. Which of the following compounds is the strongest acid?

a. CH₃COOH  

b. FCH₂COOH  

c. ClCH₂COOH  

d. BrCH₂COOH
II. (15) Draw Lewis structures for the following functional groups. You may use a generic R symbol to represent a carbon containing chain. For instance,

would represent a proper generic Lewis structure for an alkene. Your structures must clearly include all **multiple bonds** and **non-bonding electrons**.

Aldehyde
\[
\begin{array}{c}
\cdot \text{O} \\
\text{R} \cdot \text{C} \cdot \text{H}
\end{array}
\]

Carboxylic acid
\[
\begin{array}{c}
\cdot \text{O} \\
\text{R} \cdot \text{C} \cdot \text{O} \cdot \text{H}
\end{array}
\]

Alcohol
\[
\begin{array}{c}
\cdot \text{O} \\
\text{R} \cdot \text{O} \cdot \text{H}
\end{array}
\]

Amine
\[
\begin{array}{c}
\cdot \text{N} \\
\text{R} \cdot \text{N} \cdot \text{H}
\end{array}
\]

Ester
\[
\begin{array}{c}
\cdot \text{O} \\
\text{R} \cdot \text{C} \cdot \text{O} \cdot \text{R}
\end{array}
\]

III. (15) Answer the following questions:

Describe a \( \sigma^* \) orbital

A sigma orbital, in general, is located along the bond axis between the two bound atoms. The sigma\(^*\) is the anti-bonding orbital oriented along the bond axis that has a node between the nuclei.

Assign the absolute configuration of the stereocenters in the following molecules:
IV. (20) Nomenclature and structure:

Provide IUPAC names for the following structures:

<table>
<thead>
<tr>
<th>Structure</th>
<th>IUPAC Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Structure 1" /></td>
<td>2-methylpentane</td>
</tr>
<tr>
<td><img src="image2" alt="Structure 2" /></td>
<td>2,5-dimethylhexane</td>
</tr>
<tr>
<td><img src="image3" alt="Structure 3" /></td>
<td>isobutylcyclopentane or (2-methylpropyl)-cyclopentane</td>
</tr>
</tbody>
</table>

Carefully draw a proper structure for the most stable conformation of *trans*-1,2 dimethylcyclohexane.

![Structure 4](image4)
V. (20) Answer all of the questions on any two of the following three pages. Write ‘OMIT” through the page you wish omitted. Your answers must be clear and complete in order to receive complete credit. A well drawn picture is frequently worth a thousand words.

1. (10) Following is a structural formula of the prescription drug famotidine, manufactured by Merck Sharp & Dohme under the name Pepcid. The primary clinical use of Pepcid is for the treatment of active duodenal ulcers and benign gastric ulcers. Pepcid is a competitive inhibitor of histamine H₂ receptors and reduces both gastric acid concentration and the volume of gastric secretions.

![Famotidine Structural Formula](image)

(a) Complete the Lewis structure of famotidine showing all valence electrons and any formal positive or negative charges. There are no formal charges in this Lewis structure.

(b) Describe all orbitals (hybridized and unbridized) involved in the C=N and S-CH₂ bonds of the above molecule. The C=N atoms are bonded with sp² hybridized orbitals on the C and N to form a sigma bond and p orbitals on each atom overlap side-to-side to form a pi bond. S-CH₂ are bonded with sp³ hybridized orbitals on the S and C to form a sigma bond.
2. (10) Draw the three equilibrium reactions that describe the acidity of the following compounds. Your reactions must which hydrogen is most acidic.

\[
\begin{align*}
\text{H}_3\text{C} &- \text{C} - \text{OH} \quad \text{pK}_a = 4.7 \\
\text{H}_3\text{C} &- \text{C} - \text{OH} \quad \text{pK}_a = 16 \\
\text{H}_3\text{C} &- \text{O} - \text{CH}_3 \quad \text{pK}_a = 55
\end{align*}
\]

Provide an explanation of the dramatic differences in acidities of these compounds.

Resonance stabilization of the anion with the negative charge delocalized over two oxygen atoms makes this one the strongest acid.

Negative charge is localized on the electronegative oxygen atom making the alcohol more acidic than the ether.

Negative charge is localized on the less electronegative carbon atom making the ether the weakest acid of these three compounds.
3. Draw a Newman projection for the anti conformation of the following molecule:

\[
\begin{align*}
\overset{\text{HO}}{\text{C}} - \overset{\text{H}}{\text{C}} & \overset{\text{COOH}}{\text{H}} \\
\overset{\text{HOOC}}{\text{H}} & \overset{\text{OH}}{\text{C}}
\end{align*}
\]
<table>
<thead>
<tr>
<th>Element</th>
<th>Li</th>
<th>Be</th>
<th>B</th>
<th>C</th>
<th>N</th>
<th>O</th>
<th>F</th>
<th>Na</th>
<th>Mg</th>
<th>Al</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Cl</th>
<th>K</th>
<th>Br</th>
<th>I</th>
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</thead>
<tbody>
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<td>1.8</td>
<td>2.5</td>
<td>3.0</td>
<td>3.4</td>
<td>4.0</td>
<td>0.9</td>
<td>1.3</td>
<td>1.6</td>
<td>1.9</td>
<td>2.2</td>
<td>2.6</td>
<td>3.2</td>
<td>0.8</td>
<td>3.0</td>
<td>2.7</td>
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