YOUR NAME
(Last, First)

Initial of Last Name

Instructions

• Fill in your name in the space above and on the next page

• Put your discussion section number in the space provided.

• Print the initial of your last name in the box above

• Please sign the Honor Code acknowledgment on the following page

• DO NOT OPEN THIS EXAM UNTIL INSTRUCTED TO DO SO

• Provide your answers in blue or black pen. Cross mistakes out completely

• Answer questions in the spaces provided
CHEM 237-Davis, Examination I

YOUR NAME ____________________________________________

(Last, First)

University Honor Code Acknowledgment
I have neither given nor received assistance in taking this examination.

__________________________
Signature

Notes
• This exam is worth 125 points
• There are 7 Problems on pages 3-8. Make sure your exam has all the pages.
• Nothing written on page 9 will be graded-this is for scratch work
• The exam period is 50 minutes.

Points
Problem 1 _____ (50)
Problem 2 _____ (15)
Problem 3 _____ (15)
Problem 4 _____ (20)
Problem 5 _____ (25)

Total _____ (125)

EXAM BEGINS ON NEXT PAGE 3
1. Question 1. Circle the best answer/give an answer for the following statements (5 points each):

(a) If an atom X is slightly more electronegative than an atom Y then an X-Y bond:
A. Will likely be ionic in character.
B. Will not form.
C. Will have covalent character with entirely equal sharing of electrons
D. Will have covalent character with the bonding electron pair more closely associated with atom X than with atom Y.

b) Which of the following structures is NOT a constitutional isomer of octane:

![structures](image)

A. 3-methyl-3-ethylpentane
B. 3,4-dimethylhexane
C. 2-methylheptane
D. 2,3,4-trimethylhexane

c) Which of the following is the correct systematic name for structure C in the previous question?
A. 3-methyl-3-ethylpentane
B. 3,4-dimethylhexane
C. 2-methylheptane
D. 2,3,4-trimethylhexane

d) Which of the following statements holds for methane (CH₄) and ammonium ion (⁺NH₄): 
A. They are chemically indistinguishable from one another
B. They represent a pair of constitutional isomers
C. They represent a pair of conformers
D. They are isoelectronic

e) Draw a Newman projection for the most stable conformer of n-butane:

![Newman projection](image)

f) Draw 1,2,3,4,5,6-hexamethylcyclohexane with all the methyl groups in axial positions:

![6-hexamethylcyclohexane](image)
g) On the orbital schematic for ethane (CH₃CH₃) below indicate the hybrid orbitals that are involved in forming the C-C and C-H bonds.

h) Highlight the most oxidized carbon in the structure below:

i) Which of the following conformers, shown as Newman projections, is the least stable (Circle one):

j) Draw the Lewis structure for ammonia NH₃ and for the ammonium ion, *NH₄. What formal charge does the nitrogen atom bear in each case?

N charge is 0  N charge is +1
2. **Resonance I** (15 points) Cyanic Acid, HOCN, and isocyanic acid HNCO have the same pKa value (pKa=3.5). Explain, with structures, why these 2 structurally different acids have the acidity value. Use carefully drawn structures to support your answer. Include all lone pairs and formal charges where necessary.

\[
\begin{align*}
\text{Cyanic Acid} & \quad \text{HNCO} \\
\text{Isocyanic Acid} & \\
\end{align*}
\]

Deprotonation of these 2 different acids gives the same anion.
2. **Resonance II.** (15 points) Draw 3 other stable resonance contributors for this anion. Indicate the location of all non-zero formal charges. Clearly show all lone pairs of electrons and appropriate curved arrows.

![Resonance Contributors](image)

3. **Mechanism and Acid Base Chemistry (20 pts)** a) Draw an arrow-pushing mechanism for the reaction of acetic acid and hydroxide anion. Show all lone pairs, curved arrows and formal charges for full credit. Show the products of the reaction. Use the pKa values shown below to determine which side of the reaction is thermodynamically favored at equilibrium.

![Acetic Acid](image)

<table>
<thead>
<tr>
<th>Substance</th>
<th>pKa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic Acid</td>
<td>4.5</td>
</tr>
<tr>
<td>Water</td>
<td>16</td>
</tr>
<tr>
<td>Hydronium Ion</td>
<td>-1.7</td>
</tr>
</tbody>
</table>

a) Draw Mechanism Here for reaction of hydroxide with acetic acid:

![Reaction Mechanism](image)

Which side of the reaction is favored at equilibrium (circle it)?

Reactants   Products
b) Draw an arrow-pushing mechanism for the reaction of acetic acid and water. Show all lone pairs, curved arrows and formal charges for full credit. Show the products of the reaction. Use the pKa values shown above to determine which side of the reaction is thermodynamically favored at equilibrium.

\[
\text{\begin{tikzpicture}
\node (a) at (0,0) {O}\node (b) at (0.5,0) {H} \node (c) at (1,0) {\vdots} \node (d) at (1.5,0) {+} \node (e) at (2,0) {H}\node (f) at (2.5,0) {O}\node (g) at (3,0) {\vdots} \node (h) at (3.5,0) {+} \node (i) at (4,0) {H} \node (j) at (4.5,0) {O}\node (k) at (5,0) {\vdots} \node (l) at (5.5,0) {+} \node (m) at (6,0) {H} \node (n) at (0.5,1) {\vdots} \node (o) at (1,1) {+} \node (p) at (1.5,1) {H} \node (q) at (2,1) {O}\node (r) at (2.5,1) {\vdots} \node (s) at (3,1) {+} \node (t) at (3.5,1) {H} \node (u) at (4,1) {O}\node (v) at (4.5,1) {\vdots} \node (w) at (5,1) {+} \node (x) at (5.5,1) {H} ;\end{tikzpicture}}
\]

Which side of the reaction is favored at equilibrium (circle it)? Reactants Products

5a). Calculate the formal charge on the indicated atoms (6 points).

b). Draw structures for the following names (4 points).

2-bromo-3,4,4-trimethylhexane

\[
\begin{tikzpicture}
\node (a) at (0,0) {Br} \node (b) at (1,0) {H} \node (c) at (2,0) {C} \node (d) at (3,0) {H} \node (e) at (4,0) {C} \node (f) at (5,0) {H} \node (g) at (6,0) {C} \node (h) at (7,0) {C} \node (i) at (8,0) {CH_3} ;\end{tikzpicture}
\]

trans-1-chloro, 2-fluorocyclopropane

\[
\begin{tikzpicture}
\node (a) at (0,0) {Cl} \node (b) at (1,0) {C} \node (c) at (2,0) {\vdots} \node (d) at (3,0) {F} ;\end{tikzpicture}
\]
c). Compare the following pairs of molecules. For the indicated pair of hydrogen atoms, circle the one that is more acidic. For each pair, provide a BRIEF explanation for your choice (15 points).

- For the first pair, circle the hydrogen atom that is more acidic. 
  - Explanation: The resonance stabilized anion is much more stable than the anion without resonance.

- For the second pair, circle the hydrogen atom that is more acidic. 
  - Explanation: This resonance stabilized anion, with 2 C=O groups, is even more stable.

- For the third pair, circle the hydrogen atom that is more acidic. 
  - Explanation: The anion with the negative charge on the more electronegative nitrogen atom is more stable than the anion with the charge on carbon.