**YOU ARE NOT ALLOWED TO TAKE SPARE COPIES OF THIS EXAM FROM THE TESTING ROOM**

- PRINT YOUR NAME ON EACH PAGE!
- WRITE CLEARLY!
- READ THE DIRECTIONS CAREFULLY!
- MOLECULAR MODELS ARE ALLOWED
- USE BLANK PAGES AS SCRATCH PAPER
- DO NOT USE RED INK
- DON'T CHEAT, USE COMMON SENSE!

<table>
<thead>
<tr>
<th>H</th>
<th>Li Be B C N O F Ne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na Mg Al Si P S Cl Ar</td>
<td></td>
</tr>
<tr>
<td>K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr</td>
<td></td>
</tr>
<tr>
<td>Rb Sr Y Er Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe</td>
<td></td>
</tr>
<tr>
<td>Cs Ba Lu Hf Ta W Re Os Ir Pt Au Tl Pb Bi Po At Rn</td>
<td></td>
</tr>
</tbody>
</table>

Interaction Energies, kcal/mol

| H/Me | -1.0 |
| Me/Me | -2.6 |
| Me/Me | -1.4 |
| Et/Me | -0.9 |
| i-Pr/Me | -0.95 |
| t-Bu/Me | -1.1 |

**INFRARED CORRELATION CHART**

| 2200 | 2720–2820 | 3300 |
| 1710 | 3000–3100 | 3500 |

**NMR CORRELATION CHARTS**

- R - NH₂ variable and condition dependent, ca. 2 - 6 δ
- R - OH (δ, ppm)
- Alkyl 3' > 2' > 1'
YOU MUST COMPLETE THIS PAGE WITH YOUR NAME
(EVEN THOUGH YOU ALREADY DID THIS ON THE COVER PAGE)
AND ALSO GIVE YOUR ASU OR POSTING ID NUMBER
WE NEED THIS NUMBER BECAUSE YOU WOULDN'T BELIEVE THE NUMBER OF
STUDENTS WHOSE NAMES WE CAN'T READ!

Points by question
1__________/12
2__________/18
3__________/34
4__________/35
5__________/28
6__________/24
7__________/24

Points Removed for cover errors ___/2

Extra Credit_____/5

Total (incl Extra)______/175+5

**YOU ARE NOT ALLOWED TO TAKE SPARE COPIES OF THIS EXAM FROM THE TESTING ROOM**
Question 1 (12 pts.) Give the IUPAC name for the following structure.

\[
\text{[Structure Image]}
\]

Question 2 (18 pts) For the proton nmr spectrum of the provided structure, circle the hydrogen atom or atoms that would have the smallest chemical shift, and also the hydrogen atom or atoms that would have the largest chemical shift, clearly indicate which is which. **Give a BRIEF EXPLANATION that includes the term DEShIELDING.** You will need to take into account a minor resonance contributor. Include a drawing of this minor resonance contributor in your answer.

\[
\text{[Structure Image]}
\]
Question 3 (34 pts.)
a) Give a curved arrow-pushing mechanism for the following reaction. Indicate the Lewis acid and base (LA, LB) for each intermolecular step, and whether they are also Bronsted acids and bases (BA, BB). Indicate the RATE DETERMINING STEP for the mechanism.

\[
\text{H}_2\text{O} \quad \text{HCl} \text{ (catalytic)} \quad \text{H}_2\text{O} \\
\text{H}_2\text{O} \quad \text{HCl} \text{ (catalytic)} \quad \text{H}_2\text{O}
\]

b) Draw reaction energy diagram with properly labelled axes for the mechanism that you drew, Indicate the ACTIVATION ENERGY FOR EACH STEP, indicate the POSITIONS OF THE TRANSITION STATES FOR EACH STEP (but do NOT draw the transition states), indicate the REACTION EXOTHERMICITY and the RATE DETERMINING STEP.
Question 4 (35 pts.) Give the missing major organic products OR reagents/conditions as appropriate for each of the following reactions, include all non-bonding electrons. 

*clearly indicate relative stereochemistry in the products where relevant*

**a)**

\[
\begin{array}{c}
\text{H}_2 \\
Pd/C
\end{array}
\]

**b)**

\[
\text{Br}_2
\]

**c)**

**d)**

\[
\begin{array}{c}
1. \text{BH}_3.\text{THF} \\
2. \cdot\text{OH}/\text{H}_2\text{O}_2
\end{array}
\]

**e)**

\[
\text{HBr} \\
\text{CCl}_4 \text{ (inert solvent)}
\]

Extra Credit (5 pts) Dr. Gould had a conversation with his daughter about which topic?

cis- and trans- saturated and unsaturated acids and bases Markovnikov and Anti-Markovnikov
Question 5 (28 pts.) For each structure A, B and C, draw the conjugate base anion formed upon deprotonation of the indicated hydrogen atom, be sure to include ALL resonance structures where appropriate. Rank A, B and C in order of increasing Brønsted acidity. Give a BRIEF explanation.

Question 6 (24 pts.) For the following Bronsted acid/base equilibrium
a) add the curved arrow pushing for reaction in both directions
b) indicate the strong and weak acid and base on each side and GIVE AN EXPLANATION and DRAW RESONANCE CONTRIBUTORS AS APPROPRIATE
c) indicate which reaction is faster and on which side the equilibrium lies
d) indicate which acid has the smaller and which the larger pKa
Question 7 (24 pts) Provided are spectra for a compound with molecular formula $\text{C}_{10}\text{H}_{14}$.

a) Give the degrees of unsaturation ________________

b) On the infrared spectrum, indicate which peaks correspond to which functional groups (including C(sp$^3$)-H). Indicate BOTH the functional group, and where appropriate, the specific BOND in the functional group that corresponds to the peak.

c) Draw the structure and clearly indicate which hydrogens correspond to which signals in the proton NMR spectrum.