## Chem 30C, Winter 2008
### Final Exam
#### Prof. Ohyun Kwon, UCLA

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**Your Name (Please Print)**

<table>
<thead>
<tr>
<th>Question</th>
<th>Your points</th>
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<tbody>
<tr>
<td>1 (16 points)</td>
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<td>2 (9 points)</td>
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<td>13 (19 points)</td>
<td>19</td>
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<tr>
<td><strong>Total (200 points)</strong></td>
<td><strong>200</strong></td>
</tr>
</tbody>
</table>
1. (a) (6 points) Write a Fisher projection of D-mannose, a Haworth projection of α-D-mannose and a chair conformation of α-D-mannose.

<table>
<thead>
<tr>
<th>Fisher projection</th>
<th>Haworth projection</th>
<th>A chair conformer</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Fisher projection of D-mannose" /></td>
<td><img src="image2" alt="Haworth projection of α-D-mannose" /></td>
<td><img src="image3" alt="A chair conformer of α-D-mannose" /></td>
</tr>
</tbody>
</table>

D-mannose | α-D-mannose | α-D-mannose

(b) (10 points) Name the following molecules.

<table>
<thead>
<tr>
<th><img src="image4" alt="Molecule" /></th>
<th>N,N-dimethylaniline</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Molecule" /></td>
<td>tetrahydrofuran (THF)</td>
</tr>
<tr>
<td><img src="image6" alt="Molecule" /></td>
<td>tetrabutylammonium bromide (TBAB)</td>
</tr>
<tr>
<td><img src="image7" alt="Molecule" /></td>
<td>C163 annulene</td>
</tr>
<tr>
<td><img src="image8" alt="Molecule" /></td>
<td>1-butyl-4-chloro-2-iodobenzene</td>
</tr>
</tbody>
</table>
2. (9 points) All attempts to synthesize cyclopentadienone yield only a Diels-Alder adduct. On the other hand, cycloheptatrienone has been prepared by several methods and is stable. Draw a structural formula for the Diels-Alder adduct formed from two cyclopentadienones (specify relative stereochemistry). And explain what accounts for the marked difference in stability of these ketones.

- A major contributing resonance structure for cyclopentadiene has only four \( \pi \) electrons (anti-aromatic) therefore extremely unstable & highly reactive.
- On the other hand, a major contributing resonance structure for cycloheptatriene has six \( \pi \) electrons (aromatic) therefore very stable & highly unreactive.
3. (8 points) **Histamine**, an important chemical in our bodies, functions as a neurotransmitter and a potent vasodilator. It is the agent that causes many symptoms of the common cold (hence antihistamine drugs being sold over the counter). Rank the basicity of each nitrogen in histamine and explain why.

![Histamine structure](image)

A > B > C : basicity

(A) is a normal, 1° amine

- Nitrogen is sp<sup>3</sup> hybridized & least electronegative

(B) lone pair electrons on this nitrogen is sp<sup>2</sup>-hybridized
- Therefore, less prone to protonation

(C) lone pair electrons on this nitrogen is part of aromatic (6π electron) system and least available for protonation
4. (a) (3 points) Propose a structural formula for compound A, C\(_{10}H_{16}\), and account for its formation.

(b) (9 points) The value of Hofmann elimination for the determination of amine structures was first illustrated by the following series of experiments. Based on the results shown below.

<table>
<thead>
<tr>
<th>C(<em>5)H(</em>{11})N</th>
<th>1. Mel (excess), K(_2)CO(_3)</th>
<th>C(<em>7)H(</em>{15})N</th>
<th>1. Mel (excess), K(_2)CO(_3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3. heat</td>
<td></td>
<td>3. heat</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,4-pentadiene</td>
</tr>
</tbody>
</table>

i. Draw the structure of compound B.

ii. Propose two additional structures (with molecular formula C\(_5\)H\(_{11}\)N) that are also consistent with the results above.
5. (22 points) Provide structures of the products or reaction conditions.

(a) 

- Benzene $\xrightarrow{\text{condition A}}$ unknown product $\xrightarrow{\text{H}_2\text{NNH}_2, \text{KOH}}$ unknown product $\xrightarrow{\text{HO-}}$ unknown product $\xrightarrow{\text{Br}_2, \text{light}}$ unknown product
- Unknown product $\xrightarrow{\text{HCl, AlCl}_3}$ unknown product $\xrightarrow{\text{PCC, CH}_2\text{Cl}_2}$ unknown product $\xrightarrow{\text{H}_2\text{SO}_4, \text{H}_2\text{O}}$ unknown product $\xrightarrow{\text{KOH, EtOH}}$ unknown product
- Unknown product $\xrightarrow{\text{Ph}_3\text{P}=\text{CH}_2}$ unknown product

(b) 

- Unknown product $\xrightarrow{\text{Br}_2, \text{FeBr}_3}$ unknown product $\xrightarrow{\text{H}_2, \text{Ni}}$ unknown product $\xrightarrow{1. \text{condition B}}$ unknown product $\xrightarrow{2. \text{H}_2\text{O, heat}}$ unknown product

**Condition A**

- $\text{AcCl, AlCl}_3$

**Condition B**

- $\text{NaNO}_2, \text{H}_2\text{O}$
6. Propose a synthesis for the following transformations.

(a) (10 points)

(b) (6 points)

(c) (8 points)
7. Propose a synthesis for the following molecules using the given starting materials.

(a) (12 points) antihistamine histapyrrodine

(b) (8 points)
8. (14 points) Chlorination of ethylbenzene under radical reaction conditions is less regioselective than bromination as shown below. Explain why by applying a postulate proposed in 1955 by George Hammond and by drawing energy diagrams for relevant reactions.

\[
\begin{align*}
(\text{PhCO}_2)_2 & \quad \text{NBS} \\
\text{Cl}_2 & \quad \text{heat or light}
\end{align*}
\]

Heats of Reaction for Hydrogen Abstraction in Ethyl Benzene

<table>
<thead>
<tr>
<th>Reaction Step</th>
<th>( \Delta H^\circ ) (kcal/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+Br \rightarrow</td>
<td>+H \rightarrow Br</td>
</tr>
<tr>
<td>+Br \rightarrow</td>
<td>+H \rightarrow Br</td>
</tr>
<tr>
<td>+Cl \rightarrow</td>
<td>+H \rightarrow Cl</td>
</tr>
<tr>
<td>+Cl \rightarrow</td>
<td>+H \rightarrow Cl</td>
</tr>
</tbody>
</table>

(1) Rate-determining step in radical halogenation is the abstraction of a hydrogen atom by a halogen (or succinimide) radical.

(2) The table shows that (homo)benzyl chlorination is exothermic and that (homo)benzyl bromination is endothermic (or neutral).

(3) Hammond postulate states that transition state for an exothermic reaction looks more like reactant and that for an endothermic reaction resembles products.

\[
\begin{align*}
\text{RH} + \text{Cl}_2 & \quad \text{NBS} \\
\text{Cl}_2 & \quad \text{heat or light}
\end{align*}
\]

Therefore, the TS energy shift for chlorination between the benzyl chlorination and homobenzyl chloride is a lot smaller than that for bromination.

That's why benzyl bromination is exclusive &

9:1 mixture of benzyl/homobenzyl chlorination.
9. (a) (8 points) Predict the structures of the expected kinetic and thermodynamic products from addition of one mole of HBr to the following dienes.

![Chemical structures]

(b) (8 points) Provide structures of the following nucleophilic aromatic substitution and briefly explain why the reaction provides two products instead of one (simple substitution product).

![Chemical structures]

Because it undergoes the reaction via a "benzyne" intermediate.

\[ \text{NH}_2\text{H}^+ \rightarrow \text{NH}_2 \rightarrow \text{H-NH}_2 \rightarrow \text{NH}_2 \text{NH}_2 \]
10. (12 points) Predict the structures of the products of the reactions shown below. Specify the relative stereochemistry of the chiral centers in the products if there is more than one chiral center.

(a) Use of Lewis acid (Et₂AlCl) improves the endo selectivity.

(b)

(c)

(d)
11. (15 points) Show the products of the reactions shown below.

(a) \[ \text{ vinyl + PhBr } \xrightarrow{\text{Pd(OAc)}_2, \text{PPh}_3, \text{Et}_3\text{N}} \text{ product} + \text{ product} \]

(b) \[ \text{ benzyl ether } \xrightarrow{\text{heat}} \text{ product} \]

(c) \[ \text{ chorismate mutase} \]

(d) \[ \text{ OTBS} \xrightarrow{\text{Cl}_2, \text{PCy}_3, \text{PCy}_3, \text{Ph}} \text{ product} \]

TBS = t-butyldimethylsilyl
12. (a) (9 points) Which of the compounds below are expected to be UV/Vis active and which are not? Briefly explain why.

<table>
<thead>
<tr>
<th></th>
<th>Yes or No</th>
<th>Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Compound 1]</td>
<td>Yes</td>
<td>contains a highly conjugated $\pi$ system (chromophore)</td>
</tr>
<tr>
<td>![Compound 2]</td>
<td>No</td>
<td>no conjugated $\pi$ system</td>
</tr>
<tr>
<td>![Compound 3]</td>
<td>No</td>
<td>no double bond</td>
</tr>
</tbody>
</table>

(b) (4 points) Define HOMO and LUMO.

<table>
<thead>
<tr>
<th>HOMO</th>
<th>Highest Occupied Molecular Orbital</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUMO</td>
<td>Lowest Unoccupied Molecular Orbital</td>
</tr>
</tbody>
</table>

\[\text{\textcolor{red}{13}}\]
13. (19 points) There exist similarities between the mechanism of nitrous deamination of 2-aminoalcohols and the pinacol rearrangement of 1,2-diols as shown below. However, the first reaction gives ring expansion, but not the second.

(a) Show the mechanism of each rearrangement.

(b) Suggest a 2-aminoalcohol that would give cyclohexanecarbaldehyde as a product.