Chemistry 3B, Final Examination

Monday, December 16, 2002

Student name: ____________________________
Student signature: _________________________
Write TA’s name or Lecture Only: ____________

1. Please make sure that the exam has 15 pages including this one.
2. Please write your answers in the spaces provided.
3. Write clearly; illegible or ambiguous answers will be considered incorrect.
4. Only writing implements are allowed (No Calculators).

GOOD LUCK!

1. 40 points
2. 60 points
3. 60 points
4. 25 points
5. 25 points
6. 30 points
7. 30 points
8. 30 points
9. 30 points
10. 15 points
11. 15 points

Total: 360 points

MINI-PERIODIC TABLE

<table>
<thead>
<tr>
<th>I</th>
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1. Answer the following questions. Every wrong answer cancels a correct answer (40 points total).

(a) Rank the structures from most acidic to least acidic [1 = most acidic, 5 = least acidic] (8 points).

(b) Circle the compounds that upon treatment with D$_2$O$^+$ incorporate ≥ 6 deuteriums (8 points).

(c) Circle the compounds that are aromatic (8 points).

(d) Circle the amino acids that could be synthesized by the Gabriel amino acid synthesis method, i.e., starting with (EtO$_2$C)$_2$CHNPhth (8 points).

(c) Circle the compounds that give an ethyl ester as one of the products upon reaction with EtO$^-$, EtOH, Δ (8 points).
2. For each of the following reactions supply the missing reagents or major organic product in the space provided. If no reaction is expected indicate by N.R. (60 points total, 4 points each question).

(a) H₂N-CH-CH₂-OH

(b) OEt

(c) NaOH (1 equiv), H₂O, (t-BuO₂)₂O

(d) piperidine

(e) N₃
(f) 1. $\text{C}_4\text{H}_{10}, \text{H}_2\text{O}$

(g) $\text{NaOH, H}_2\text{O, Cl}_2$

(h) $\text{E}\text{E}$

(i) 6-11

(j) 1. $\text{MBr}_5$, $\text{CCl}_4$, $\text{hv}$
(k)  
\[
\text{NaOH, } \text{H}_2\text{O, } \Delta \\
\alpha \text{-dialdehyde}
\]

(l)  
\[
\text{LiAlH}_4, \text{ then aqueous work-up}
\]

(m)  
\[
\text{1. } \text{Cr}_2\text{O}_7^{2-}, \text{H}_2\text{SO}_4, \text{H}_2\text{O}
\]

(n)  
\[
\text{1. } \text{H}^+, \text{Cl}_2.
\]

(o)  
\[
\text{1. } \text{H}_2\text{NNH}_2, \text{H}_2\text{O}, \Delta
\]

(or 2\text{C}(13), \text{HCl}, \Delta)

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3. For each of the following reactions supply the missing reagents or major organic product in the space provided. If no reaction is expected indicate by N.R. (60 points total, 6 points each question).

(a) [Chemical structure diagram]
1. H₃O⁺, H₂O, Δ
2. MeNH₂, EtOH, NaBH₃CN

(b) [Chemical structure diagram]
1. N₆N₃, DMF
2. Li/THF, then aqueous work-up

(c) [Chemical structure diagram]
1. Na, CN, DMF
2. LiAlH₄, then aqueous work-up

(d) [Chemical structure diagram]
1. LiAl[OCH(CH₃)₃]₃H, then aqueous work-up
2. HCN, NH₃
3. H₃O⁺, H₂O, Δ

(e) [Chemical structure diagram]
1. Br₂, FeBr₃
2. Mg, et al
3. 2n(H₂), HCl, Δ
4. CO₂, H⁺/H₂O

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(f)  
1. NaOH, H₂O, Δ  
2. Et₂CuLi, then aqueous work-up

(g)  
1. SOCl₂, Δ  
2. H₂O, MeOH, Δ  
3. σ-one, MeOH, MeBr (100%) (C₂H₅)₂NCl₂

(h)  
1. AlCl₃, Cl⁻Cl  
2. AlCl₃, Cl⁻  
3. MeOH, HCl, sieves

(i)  
1. NBS, hv, CCl₄  
2. NaN₃  
3. LiAlH₄, aq. work-up

(j)  
1. LDA  
2. PhCH₂Br  
3. F₃CCO₂H
4. Provide a mechanism for the below transformation (25 points).

This type of reaction is called the Pictet Spengler reaction and can be used to synthesize morphine, vicodin, and related compounds.
5. Orthoesters are used as protecting groups for esters. Provide a mechanism for the orthoester to ester transformation shown below (25 points).
6. Provide a mechanism for the below transformation. Hint: think about the relationship of the below transformation to the Robinson annulation (30 points).
7. Provide the most efficient solid-phase synthesis of Gly-Ala-Asp-Phe from any protected amino acids (30 points).
8. Provide the most efficient synthesis (30 points).

\[
\text{from 3 equiv of } \quad \text{HO-CH}_2-\text{CH}_2-\text{CHO}
\]

\[
\text{and any other reagents}
\]

\[
\text{\textbf{Step 1:}}
\]

\[
\text{\textbf{Step 2:}}
\]

\[
\text{\textbf{Step 3:}}
\]

\[
\text{\textbf{Step 4:}}
\]

\[
\text{\textbf{Step 5:}}
\]

\[
\text{\textbf{Step 6:}}
\]

\[
\text{\textbf{Step 7:}}
\]

\[
\text{\textbf{Step 8:}}
\]

\[
\text{\textbf{Step 9:}}
\]

\[
\text{\textbf{Step 10:}}
\]
9. Provide the most efficient synthesis (30 points).

[Chemical diagram and reactions are shown with text annotations and arrows indicating reaction steps.]

- From 2 equiv of \( \text{HO-C} \) and \( \text{C} \) and any other reagents
10. The cyclopropenone shown below forms an addition product with HBr that exhibits the properties of an ionic salt. Suggest a structure for this product and a reason for its existence as a stable entity. (15 points).

The addition product is stable due to the presence of three aromatic rings allowing for many stabilizing resonance structures:

11. There are two types of hydrogens, H₁ and H₀, present in the [14]annulene shown below. In the proton NMR spectra two peaks are observed, one at -0.61 ppm and one at 7.88 ppm. Assign these peaks to either H₁ or H₀. Provide a brief explanation for your answer (15 points).

The aromatic ring induces an H field on the inner protons that opposes H₀, shielding the protons. The outer protons, on the other hand, are deshielded by the induced H field, as H₁ is in the same direction as H₀.