General Organic Chemistry
Chapters 16-18
January 28, 2009

Multiple Choice (3 points each)

1. What is the hybridization of carbon in ethanol?
   a) p
   b) sp
   c) sp²
   d) sp³
   e) sp³d

2. What is the closest measure of the indicated bond angle in ethanol?
   a) 90°
   b) 120°
   c) 109°
   d) 180°
   e) 270°

3. Classify the following alcohol as a 1°, 2°, or 3° alcohol.
   a) 1°
   b) 2°
   c) 3°

4. What is the expected intermediate in the nitration of toluene?
   a)
   b)
5. Which of the following best describes alcohols:
   a) strong base
   b) strong acid
   c) weak acid
   d) grignard reagent

6. NO₂ in p-nitrophenol is a(n)

   a) electron donating group
   b) electron withdrawing group
   c) grignard reagent

7. Select all of the following that are capable of hydrogen bonding (there is more than one answer)?
   a) butanol
   b) 2-bromohexane
   c) 2-methyl-2-propanol
   d) Phenol
   e) cyclohexane

Consider the reaction below to answer questions 7-8.

8. This reaction can best be classified as a
   a) An oxidation reaction
   b) An SN2 reaction
   c) A Grignard reaction
   d) A claisen rearrangement

9. Product C can be classified as a:
   a) 1° alcohol
   b) 2° alcohol
   c) 3° alcohol
   d) ketone
   e) aldehyde
10. Which of the following could be used in the conversion below?

- NaBH₄
- LiAlH₄
- CrO₃, H₂SO₄
- SOCl₂
- PCC

11. The O-H stretch in an alcohol will show up in the IR at
   a) 300 cm⁻¹
   b) 1200 cm⁻¹
   c) 1710 cm⁻¹
   d) 2950 cm⁻¹
   e) 3300 cm⁻¹

12. The reduction of the ketone below with LiAlH₄ yields

- an aldehyde first, then a primary alcohol
- a primary alcohol
- a secondary alcohol
- a tertiary alcohol
- a carboxylic acid

13. The following tests were conducted on an unknown alcohol. Select the compound below that would best match the results of these tests.

<table>
<thead>
<tr>
<th>Test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromic Acid (Jones)</td>
<td>Solution appears orange</td>
</tr>
<tr>
<td>Lucas Test</td>
<td>Bubbles and cloudiness appears immediately</td>
</tr>
<tr>
<td>Cerium Nitrate Test</td>
<td>Solution appears dark red</td>
</tr>
</tbody>
</table>

- a
- b
- c
- d
Consider the reaction below to answer questions 14-15.

\[
\begin{align*}
\text{OH} & \quad \text{1. NaH} \\
& \quad \text{2. CH}_3\text{CH}_2\text{I}, \text{ether}
\end{align*}
\]

14. The Williamson ether synthesis outlined above is:
   a) An E1 process
   b) An S_n1 process
   c) An E2 process
   d) An S_n2 process

15. Write the complete stepwise mechanism for this reaction. Show all intermediate structures and all electron flow with arrows. (4 points)

16. Draw structures corresponding to the following IUPAC names: (2 points each)
   a) trans-3-isopropylcyclohexanol
   b) 3-methyl-2,4-hexanediol
   c) propylmethylether

17. Rank the following groups of compounds from most acidic (1) to least acidic (3). Place the number corresponding to the compound’s relative rank in the blank below the structure. (3 points)

\[
\begin{array}{ccc}
(CF_3)_2\text{CHOH} & \text{CH}_3\text{C}≡\text{C-H} & \text{CH}_2\text{CH}_2\text{OH} \\
& 1 & \text{?}
\end{array}
\]
18. Rank the following groups of compounds from most acidic (1) to least acidic (3). Place the number corresponding to the compound’s relative rank below the structure. (3 points)

19. Give the major organic product(s) of the following reactions or sequences of reactions. (12 points)
20. Choose the best reagent(s) or predict the products for carrying out the following conversions. (6 points)

\[ \text{[Chemical structure]} \xrightarrow{\text{H}_{3}O^{+}} \text{[Chemical structure]} \]

\[ \text{[Chemical structure]} \xrightarrow{\text{PCC}} \text{[Chemical structure]} \]

\[ \text{[Chemical structure]} \xrightarrow{\text{[Chemical structure]}} \text{[Chemical structure]} \]

21. Show the mechanism and predict the major product of the reaction shown below. Show the labeled oxygen, $^{18}\text{O}$, in the final product. (2 points for the correct product + 2 points for the mechanism = 4 total points possible)

\[ \text{[Chemical structure]} \xrightarrow{\text{[Chemical structure]}} \text{[Chemical structure]} \]
Choose the best reagent for carrying out the following reactions from the list below. Place the letter of the reagent(s) in the box over the reaction arrow. You may only use one letter per box. (12 points)

A. Na or NaH, then CH₃I
B. NaOCH₃, CH₃OH
C. m-C₆H₄CO₂H
D. CH₃MgBr in ether, then H₃O⁺
E. warm H₂SO₄/H₂O
F. Hg(OAc)₂, CH₃OH
G. -H₂/Pd
H. Na₂Cr₂O₇, Chromic acid, (Jones Reagent)
I. -Cl₂, H₂O
J. LiAlH₄ in ether, then H₂O⁺
23. Complete the following reactions:

\[
\begin{align*}
&\text{OH} \\
&\text{C}_6\text{H}_5\text{OH} \xrightarrow{\text{HNO}_3} \text{C}_6\text{H}_5\text{NO}_2 \\
&\text{C}_6\text{H}_5\text{OH} \xrightarrow{\text{H}_2\text{SO}_4} \text{C}_6\text{H}_5\text{NO}_2 \\
&\text{C}_6\text{H}_6 \xrightarrow{\text{Br}_2} \text{C}_6\text{H}_5\text{Br} \\
&\text{C}_6\text{H}_6 \xrightarrow{\text{FeBr}_3} \text{C}_6\text{H}_5\text{Br} \\
&\text{C}_6\text{H}_6 \xrightarrow{\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}} \text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl} \\
&\text{C}_6\text{H}_6 \xrightarrow{\text{AlCl}_3} \text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl} \\
&\text{C}_6\text{H}_6 \xrightarrow{\text{Cl} \text{C}_2\text{CH}_2\text{CH}_2\text{CH}_2} \text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl} \\
&\text{C}_6\text{H}_6 \xrightarrow{\text{AlCl}_3} \text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl} \\
&\text{C}_6\text{H}_6 \xrightarrow{\text{H}_2, \text{Pd}} \text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{CH}_2\text{H} \\
\end{align*}
\]

24. At what position would you expect electrophilic substitution to occur in the following substances? Put a check mark by the carbon where the most likely substitution would occur. (Example: Add Cl\textsubscript{2} in AlCl\textsubscript{3}. Which carbon would the chlorine add to?)