Final Exam – CHM1321-B

Professor Sandro Gambarotta

Date: April 2018      Length: 3 hrs

Last Name: _______________________
First Name: _______________________
Student # ____________
Seat# ___________

- Instructions:
  - Molecular Model Kit recommended
  - Closed book exam
  - Periodic and electronegativity tables allowed
  - Non programmable calculators allowed

Cellular phones, unauthorized electronic devices or course notes (unless an open-book exam) are not allowed during this exam. Phones and devices must be turned off and put away in your bag. Do not keep them in your possession, such as in your pockets. If caught with such a device or document, the following may occur: you will be asked to leave immediately the exam, academic fraud allegations will be filed which may result in you obtaining a 0 (zero) for the exam.

Read carefully:

By signing below, you acknowledge that you have read and ensured that you are complying with the statement below.

Signature: _________________________
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<td>.... / 45</td>
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1. **(1 point)** What is the IUPAC name of the following compound?

![Chemical Structure](image)

ANS: 1-isopropyl-2,4-dimethylcyclohexane
2. (1 point) Which of the following Newman projections represents 2,4-dimethylpentane?

\[ \text{ANS: } 1 \]

3. (2 points) Draw (correctly) the most stable conformation of \((\text{cis})-1\)-isopropyl-3-methylcyclohexane.

\[ \text{ANS: } 3 \]

4. (2 point) Which of the following compounds is/are chiral?
ANS: only 1

5. (1 point) Which of the following have the S configuration?

ANS: 1 and 2

6. (1 point) Which of the following compounds is a meso compound?

(2R,3R)-dibromobutane
(2R,3S)-dibromobutane
(2R,3S)-3-bromo-2-butanol
(2R,3R)-3-bromo-2-butanol

ANS: (2R,3S)-dibromobutane

7. (3 point) What is the relationship between the following pair of structures?
ANS: diastereomers

8. (2 point) Draw the Fisher formula of (2R,3S)-3-bromo-2-butanol

ANS:

\[
\begin{align*}
\text{HO} & \quad \text{H} \\
\text{Br} & \quad \text{H} \\
\text{CH}_3 & \quad \text{CH}_3
\end{align*}
\]

9. (2 point) By using the table of pKa at the end of this booklet, would you expect that phenylthiol (C₆H₅)SH is able to protonate the acetylacetonate anion?

ANS: yes

10. (1 point) Which of the following alkenes is most likely to undergo skeletal rearrangement upon acid-catalyzed hydration (treatment with aqueous H₂SO₄)?
11. (5 point) Draw the curved arrow mechanism and the major organic product obtained from the following reaction. Specify the stereochemistry of the product (cis or trans)

\[
\text{CH}_3
\]

1. BH₃
2. H₂O₂, NaOH

ANS:

\[
\text{+ enantiomer}
\]

12. (2 point) What is the major organic product obtained from the following reaction?
13. (3 point) Provide a neatly drawn mechanism for the following reaction, including curved arrows to show the movement of pairs of electrons and the structure of reactive intermediates.

\[
\text{\begin{tikzpicture}[scale=0.8]
  \node (a) at (0,0) {\text{CH}_3} ;
  \node (b) at (1,0) {\text{CH}_3} ;
  \node (c) at (2,0) {\text{H}_2\text{C}} ;
  \node (d) at (3,0) {\text{HO}-\text{CH}_3} ;
  \draw[->,thick] (a) -- (b) node[midway, right] {\text{Hg(OAc)}_2} ;
  \draw[->,thick] (b) -- (c) node[midway, right] {\text{NaBH}_4} ;
\end{tikzpicture}}
\]

ANS: 3
14. (3 point) Provide a detailed mechanism for the reaction below showing the movement of pairs of electrons and the structure of reactive intermediates.

ANS:
15. (1 point) What is the major organic product obtained from the following reaction?

\[
\begin{align*}
&\text{CH}_3\text{CO}_2\text{H} \\
&\text{C}_2\text{H}_4 \\
\end{align*}
\]

ANS: 3

16. (1 point) What is the major organic product obtained from the following reaction?

\[
\begin{align*}
&\text{H}_2\text{O} \\
&\text{H}_3\text{C} \\
\end{align*}
\]

ANS: 1

17. (3 point) What is the major organic product obtained from the following sequence of reactions?
ANS: 2-methylbutane

18. (4 points) What is the major organic product obtained from the following reaction?

ANS: 3

19. (2 points) What is the major organic product obtained from the following reaction?
20. (2 points) What is the major organic product obtained from the following sequence of reactions?

ANS: 2-pentanol

21. (1 point) Specify which of the following ions is aromatic, antiaromatic and non-aromatic?

ANS: 1 = anti
2 = aromatic
3 = anti
4 = non
22. (2 point) What is(are) the major organic product(s) obtained from the following reaction?

\[ \text{ANS: both ortho and para bromo-toluene isomers} \]

23. (2 points) What is the major organic product obtained from the following reaction?

\[ \text{ANS:} \]
24. (1 point) Which of the following undergoes the most rapid nitration upon treatment with HNO₃/H₂SO₄?

a. toluene  
b. benzene  
c. bromobenzene  
d. nitrobenzene

ANS: A

25. (3 point) What is the major organic product obtained from the following reaction?

[Diagram of the reaction involving aromatic compound with COOH and CH₃ groups, and the reagents Br₂ and FeBr₃]

ANS:
<table>
<thead>
<tr>
<th>Compound</th>
<th>$pK_a$</th>
<th>Compound</th>
<th>$pK_a$</th>
<th>Compound</th>
<th>$pK_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBr</td>
<td>-9</td>
<td>$\text{C}_6\text{H}_5\text{CO}_2\text{H}$</td>
<td>4.2</td>
<td>$\text{CH}_2(\text{C}≡\text{N})_2$</td>
<td>11</td>
</tr>
<tr>
<td>H$\text{C}_6\text{H}_5\text{CO}_2\text{H}$</td>
<td>-8</td>
<td>$\text{C}_6\text{H}_5\text{NH}_3^+$</td>
<td>4.6</td>
<td>$\text{H}_2\text{O}_2$</td>
<td>11.6</td>
</tr>
<tr>
<td>H$\text{C}_6\text{H}_5\text{CO}_2\text{H}$</td>
<td>-6</td>
<td>CH$_3$CO$_2$H</td>
<td>4.8</td>
<td>$\text{CCl}_3\text{C}_2\text{H}_5\text{OH}$</td>
<td>12.2</td>
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<tr>
<td>H$_2$</td>
<td>-7</td>
<td>$\text{H}_2\text{CO}_3$</td>
<td>5.2</td>
<td>$\text{CH}_3$</td>
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<td>$\text{H}_2\text{S}$</td>
<td>6.4</td>
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<td>12.9</td>
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<tr>
<td>H$_2$C$\text{O}_2$H</td>
<td>-3.8</td>
<td>$\text{H}_2\text{O}$</td>
<td>6.9</td>
<td>$\text{CH}_2$CHO</td>
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<td>$\text{CH}_3\text{SO}_3\text{H}$</td>
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<td>H$_2$O$_4$</td>
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<td>$\text{CH}_3\text{C}(\text{O})\text{OH}$</td>
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<td>$\text{CH}_3$OH</td>
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<td>HNO$_3$</td>
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<td>$\text{CH}_3\text{CO}_2$H</td>
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<td>$\text{H}_2\text{O}$</td>
<td>15.7</td>
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<td>CF$_3$CO$_2$H</td>
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<td>CH$_3$CO$_2$H</td>
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<td>CCl$_3$CO$_2$H</td>
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<td>NH$_4^+$</td>
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<td>CHCl$_2$CO$_2$H</td>
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<td>H-C=N</td>
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<tr>
<td>CH$_3$(NO$_2$)CO$_2$H</td>
<td>1.6</td>
<td>$\text{O}^\text{H}$</td>
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<td>$\text{HC}≡\text{CH}$</td>
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<td>H$_2$PO$_4$</td>
<td>2.1</td>
<td>(CH$_3$)$_2$NH$_3^+$</td>
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<td>N=C-CH$_3$</td>
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<td>CH$_2$C(CO$_2$H)</td>
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<td>NH$_3^+$</td>
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<td>O$^\text{H}$</td>
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<td>$\text{C}_6\text{H}_5$</td>
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<td>HCO$_2$H</td>
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<td>$\text{CH}_2=\text{CH}–\text{CH}_3$</td>
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<td>CH$_2=\text{CH}_2$</td>
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