Chem 2300 - Final Exam

December 9, 2010

Name: ____________________________ (First) ____________________________ (Last) (Please print)

<table>
<thead>
<tr>
<th>Last 4 digits of Banner No.</th>
<th>Score</th>
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<tbody>
<tr>
<td>I. Multiple Choice</td>
<td>/180</td>
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<td>( /60)</td>
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<tr>
<td>II</td>
<td>/10</td>
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<tr>
<td>III</td>
<td>/10</td>
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</tbody>
</table>

Total score /200

Note: Periodic Table, pK\(a\), and pK\(b\) values are on pages 21 and 22.
I. Multiple choice questions. (3 points each). Please put your answers on Scantron sheet.

1. 1. Using the VSEPR model, predict which atoms pointed by an arrow have $SP^2$ hybridization. (Note: not all the lone pair electrons are displayed)

(a) I, II, IV, VIII
(b) I, III, V, VII
(c) II, III, V, VII
(d) II, IV, V, VIII
(e) None of the above

2. Arrange the following compounds in order of their acidity. (most to least)

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH$_3$CH$_2$OH</td>
<td>CFH$_2$CO$_2$H</td>
<td>CF$_2$HCO$_2$H</td>
<td>CF$_3$CO$_2$H</td>
<td>CH$_3$CO$_2$H</td>
</tr>
</tbody>
</table>

(a) IV$>$III$>$II$>$I$>$V
(b) IV$>$III$>$II$>$V$>$I
(c) V$>$III$>$IV$>$II$>$I
(d) V$>$II$>$III$>$IV$>$I
(e) None of the above

3. Which of the following can best explain the tendency of acidity for the compounds in Q.2?

(a) Octet rule
(b) Inductive effect
(c) Resonance effect
(d) Tautomerization
(e) None of the above
4. Arrange the following compounds in order of their basicity. (most to least)

(a) III>II>I>IV  
(b) I>III>II>IV  
(c) II>III>I>IV  
(d) II>I>III>IV  
(e) None of the above

5. Which of the following can best explain why compound IV in Q.4 is the least basic?

(a) Octet rule  
(b) Inductive effect  
(c) Resonance effect  
(d) Tautomerization  
(e) None of the above

6. Which of the following can best describe the relationship between compound I and II?

(a) They are structural isomer to each other.  
(b) They are diastereomer to each other.  
(c) They are enantiomer to each other.  
(d) If mixed in 1/1 ratio, they can form racemic mixture.  
(e) None of the above
7. Which of the following can best describe the relationship between compound I and II?

(a) They are structural isomer to each other.
(b) They are diastereomer to each other.
(c) They are enantiomer to each other.
(d) They are identical.
(e) None of the above

8. Which of the following can best describe the relationship between compound I and II?

(a) They are structural isomer to each other.
(b) They are diastereomer to each other.
(c) They are enantiomer to each other.
(d) They are identical.
(e) None of the above

9. Which of the following functional group can be found in compound II of Q.8?

(a) Ether
(b) Acetal
(c) Hemiacetal
(d) Hemiketal
(e) None of the above
10. Which of the following can best describe the relationship between compound I and II?

\[
\text{I} \quad \alpha\text{-D-glucopyranose} \quad \text{II} \quad \alpha\text{-D-glucofuranose}
\]

(a) They are structural isomer to each other.
(b) They are diastereomer to each other.
(c) They are enantiomer to each other.
(d) They are identical.
(e) None of the above

11. How many chiral carbon present on compound I of Q.10?

(a) 3
(b) 4
(c) 5
(d) 6
(e) None of the above

12. Arrange the following compounds in order of their acidity. (most to least)

\[
\text{I} \quad \text{II} \quad \text{III} \quad \text{IV}
\]

(a) IV>III>II>I
(b) IV>II>III>I
(c) III>IV>II>I
(d) II>III>IV>I
(e) None of the above
13. Which of the following can best explain the tendency of acidity for the compounds in Q.12?

(a) Octet rule  
(b) Inductive effect  
(c) Resonance effect  
(d) Tautomerization  
(e) None of the above

14. What is the name for the following compound?

\[
\begin{array}{ccc}
\text{OCH}_3 & (a) & \text{p-methylphenol} \\
\text{CH}_3 & (b) & \text{m-methylphenol} \\
& (c) & \text{o-methylanisole} \\
& (d) & \text{m-methylanisole} \\
& (e) & \text{None of the above}
\end{array}
\]

15. Which of the following compounds are aromatic compounds?

(a) I, II, III, IV, V, VI, VIII, X, XII  
(b) I, II, III, V, VII, VIII, IX, X, XII  
(c) I, II, III, VI, VIII, X, XI, XII  
(d) I, II, III, IV, V, VI, VII, X, XII  
(e) None of the above

16. Cinnamaldehyde is the organic compound that gives cinnamon its flavor. What is the IUPAC name for cinnamaldehyde?

(a) \((E)-3\text{-phenylprop-2-enal}\)  
(b) \((E)-3\text{-benzylprop-2-enal}\)  
(c) \((E)-3\text{-phenylprop-1-enal}\)  
(d) \((E)-3\text{-benzylprop-1-enal}\)  
(e) None of the above
17. Which of the following compounds should be thermodynamically most stable?

(a) I  
(b) II  
(c) III  
(d) IV  
(e) None of the above

18. NAD\(^+\) is a common co-enzyme involved in biological redox (reduction/oxidation) processes. Without specifying the R group, which nicotinamide (circled) group is aromatic?

(a) The one circled in NAD\(^+\) because there are 6 \(\pi\) electrons in the aromatic ring.  
(b) The one circled in NADH because there are 6 \(\pi\) electrons in the aromatic ring.  
(c) The one circled in NAD\(^+\) because there are 10 \(\pi\) electrons in the aromatic ring.  
(d) The one circled in NADH because there are 10 \(\pi\) electrons in the aromatic ring.  
(e) None of the above

19. Which is the electronic configuration that describes Mg?

(a) 1S\(^2\), 2S\(^2\)  
(b) 1S\(^2\), 2S\(^2\), 2P\(^6\)  
(c) 1S\(^2\), 2S\(^2\), 2P\(^6\), 3S\(^2\)  
(d) 1S\(^2\), 2S\(^2\), 2P\(^6\), 3S\(^2\), 3P\(^6\)  
(e) none of the above
20. Which of the following molecules are non-polar?

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃</td>
<td>CO₂</td>
<td>H₂O</td>
<td>CF₄</td>
<td>Br₂</td>
<td>CH₂Cl₂</td>
</tr>
</tbody>
</table>

(a) I, II, IV, VI  
(b) II, IV, V  
(c) I, III, VI  
(d) I, III, IV, V  
(e) None of the above

21. How many 3° carbons are there in the following molecules?

(a) 1  
(b) 2  
(c) 3  
(d) 4  
(e) 5

22. What is the name of the following compound?

(a) (E)-1-bromo-1-fluoro-3-methyl-1-pentene  
(b) (E)-1-bromo-1-fluoro-3-ethyl-1-butene  
(c) (Z)-1-bromo-1-fluoro-3-methyl-1-pentene  
(d) (Z)-1-bromo-1-fluoro-3-ethyl-1-butene  
(e) None of the above

23. What is the name of the following compound?

(a) (R)-3-isopropyl-1-methylcyclohexene  
(b) (R)-5-isopropyl-1-methylcyclohexene  
(c) (S)-5-isopropyl-1-methylcyclohexene  
(d) (S)-3-isopropyl-1-methylcyclohexene  
(e) None of the above

24. What is the order of stability for the following conformational isomers of n-butane (most to least)?

(a) I>II>III>IV  
(b) I>IV>II>III  
(c) I>IV>III>IV  
(d) I>II>IV>III  
(e) None of the above
25. What is the order of stability for the following isomers (most to least)?

(a) II > I > III > IV
(b) II > IV > I > III
(c) III > II > I > IV
(d) II > III > I > IV
(e) None of the above

26. What is the structure of 3-methylcyclopentanethiol?

(a) I
(b) II
(c) III
(d) IV
(e) None of the above

27. What’s the name for the following compound?

(a) 1-ethyl-1-methylbutanamine
(b) N-ethyl-N-methylbutanamine
(c) N-ethyl-N-methyl-1-butanamine
(d) N-methyl-N-ethylbutanamine
(e) None of the above

28. What’s the name for the following compound?

(a) 4-bromoaniline
(b) m-bromoaniline
(c) 4-chloroaniline
(d) m-chloroaniline
(e) None of the above
29. Which of the following alcohol would be most soluble in water?

(a) \( \text{OH} \)  
(b) \( \text{OH} \)  
(c) \( \text{OH} \)  
(b) \( \text{OH} \)  

(e) None of the above

30. Which of the following does not represent a pair of stereoisomer?

(a) \( \text{and} \)  
(b) \( \text{and} \)  
(c) \( \text{and} \)  
(d) \( \text{and} \)  

(e) None of the above

Answer questions 31 - 40 based on the following scheme:
31. What should be the structure of I?
   (a) \[
   \begin{array}{c}
   \text{CH}_3 \\
   \text{苯}
   \end{array}
   \] 
   (b) \[
   \begin{array}{c}
   \text{SO}_3\text{H} \\
   \text{苯}
   \end{array}
   \] 
   (c) \[
   \begin{array}{c}
   \text{NO}_2 \\
   \text{苯}
   \end{array}
   \] 
   (d) \[
   \begin{array}{c}
   \text{CO}_2\text{H} \\
   \text{苯}
   \end{array}
   \] 
   (e) None of the above

32. What should be the structure of II?
   (a) \[
   \begin{array}{c}
   \text{CH}_3 \\
   \text{苯}
   \end{array}
   \] 
   (b) \[
   \begin{array}{c}
   \text{SO}_3\text{H} \\
   \text{苯}
   \end{array}
   \] 
   (c) \[
   \begin{array}{c}
   \text{NO}_2 \\
   \text{苯}
   \end{array}
   \] 
   (d) \[
   \begin{array}{c}
   \text{CO}_2\text{H} \\
   \text{苯}
   \end{array}
   \] 
   (e) None of the above

33. What should be the structure of III?
   (a) \[
   \begin{array}{c}
   \text{CH}_3 \\
   \text{苯}
   \end{array}
   \] 
   (b) \[
   \begin{array}{c}
   \text{SO}_3\text{H} \\
   \text{苯}
   \end{array}
   \] 
   (c) \[
   \begin{array}{c}
   \text{NO}_2 \\
   \text{苯}
   \end{array}
   \] 
   (d) \[
   \begin{array}{c}
   \text{CO}_2\text{H} \\
   \text{苯}
   \end{array}
   \] 
   (e) None of the above

34. What should be the structure of IV?
   (a) \[
   \begin{array}{c}
   \text{苯 серии} \\
   \text{O}
   \text{CH}_3
   \end{array}
   \] 
   (b) \[
   \begin{array}{c}
   \text{苯 серии} \\
   \text{O}
   \text{CH}_3
   \end{array}
   \] 
   (c) \[
   \begin{array}{c}
   \text{苯 серии} \\
   \text{O}
   \text{CH}_3
   \end{array}
   \] 
   (d) \[
   \begin{array}{c}
   \text{苯 серии} \\
   \text{O}
   \text{CH}_3
   \end{array}
   \] 
   (e) None of the above

35. What should be the structure of V?
   (a) \[
   \begin{array}{c}
   \text{苯 серии} \\
   \text{O}
   \text{CH}_3
   \end{array}
   \] 
   (b) \[
   \begin{array}{c}
   \text{苯 серии} \\
   \text{O}
   \text{CH}_3
   \end{array}
   \] 
   (c) \[
   \begin{array}{c}
   \text{苯 серии} \\
   \text{O}
   \text{CH}_3
   \end{array}
   \] 
   (d) \[
   \begin{array}{c}
   \text{苯 серии} \\
   \text{O}
   \text{CH}_3
   \end{array}
   \] 
   (e) None of the above
36. What should be the structure of VI?
(a) Mg
(b) MgBr
(c) MgBr₂
(d) Mg₂Br
(e) None of the above

37. What should be the structure of VII?
(a) 
(b) 
(c) 
(d) 
(e) None of the above

38. What could be reagent A?
(a) Br₂/FeBr₃
(b) Cl₂/FeCl₃
(c) Fuming sulfuric acid
(d) HNO₃/H₂SO₄
(e) None of the above

39. What could be reagent B?
(a) CH₃OH
(b) CH₃CH₂OH
(c) HOCH₂CH₂OH
(d) CH₃CHO
(e) None of the above

40. What could be reagent C?
(a) CH₃OH
(b) CH₃CH₂OH
(c) HOCH₂CH₂OH
(d) CH₃CHO
(e) None of the above
Answer questions 41 - 47 based on the following scheme:

41. What could be reagent A?
(a) \( \text{CH}_3\text{CHOH} \)  
(b) \( \text{CH}_3\text{COCI} \)  
(c) \( \text{CH}_3\text{CO} \)  
(d) \( \text{CH}_3\text{Cl} \)  
(e) None of the above

42. What could be reagent B?
(a) \( \text{H}_3\text{O}^+ \)  
(b) \( \text{H}_2, \text{Pt} \)  
(c) \( \text{HCl} \)  
(d) \( \text{Cl}_2/\text{AlCl}_3 \)  
(e) None of the above

43. What should be the structure of I?
(a) 
(b) 
(c) 
(d) 
(e) None of the above

44. What should be the structure of II?
(a) 
(b) 
(c) 
(d) 
(e) None of the above
45. What should be the structure of III?

(a)  
(b)  
(c)  
(d)  
(e) None of the above

46. What should be the structure of IV?

(a)  
(b)  
(c)  
(d)  
(e) None of the above

47. What should be the structure of V?

(a)  
(b)  
(c)  
(d)  
(e) None of the above

Answer questions 48 - 56 based on the following scheme:

Answer questions 48 - 56 based on the following scheme:

IV  \xrightarrow[CrO_3, H_2SO_4]{H^+, H_2O, \text{removal of water}} \text{OH} \xrightarrow{\text{A}} \text{Cl} \xrightarrow{\text{B}, \text{MgCl}} \text{OH} \xrightarrow{1) \text{C}} \text{OH} \xrightarrow{2) H^+, H_2O} \text{CHO} \\
\text{C} \xrightarrow{\text{E} \xrightarrow{\text{H}^+, \text{H}_2\text{O}} \text{III}} \\
\text{CH}_2\text{NH}_2, \text{H}^+ \xrightarrow{\text{II}} \text{removal of water} \\
\text{I}  \xrightarrow[\text{CrO}_3, \text{H}_2\text{SO}_4]{1) \text{CH}_2\text{CH}_2\text{MgBr} \xrightarrow{2) \text{H}^+, \text{H}_2\text{O}}
48. What could be reagent A?
   (a) RCO₂H
   (b) Mg, Et₂O
   (c) HCl
   (d) PCC
   (e) None of the above

49. What could be reagent B?
   (a) RCO₂H
   (b) Mg, Et₂O
   (c) HCl
   (d) PCC
   (e) None of the above

50. What could be reagent C?
   (a) HCO₂H
   (b) HCHO
   (c) CH₃OH
   (d) CO₂
   (e) None of the above

51. What could be reagent D?
   (a) RCO₂H
   (b) Mg, Et₂O
   (c) HCl
   (d) PCC
   (e) None of the above

52. What could be reagent E?
   (a) RCO₂H
   (b) Mg, Et₂O
   (c) HCl
   (d) PCC
   (e) None of the above

53. What should be the structure of I?

(a) [Diagram of structure]
(b) [Diagram of structure]
(c) [Diagram of structure]
(d) [Diagram of structure]

(e) None of the above
54. What should be the structure of II?
(a) \[ \text{[structure]} \]  
(b) \[ \text{[structure]} \]  
(c) \[ \text{[structure]} \]  
(d) \[ \text{[structure]} \]  
(e) none of the above

55. What should be the structure of III?
(a) \[ \text{[structure]} \]  
(b) \[ \text{[structure]} \]  
(c) \[ \text{[structure]} \]  
(d) \[ \text{[structure]} \]  
(e) none of the above

56. What should be the structure of IV?
(a) \[ \text{[structure]} \]  
(b) \[ \text{[structure]} \]  
(c) \[ \text{[structure]} \]  
(d) \[ \text{[structure]} \]  
(e) none of the above

57. What could be the product for the following reaction?
\[ \text{[structure]} \text{CH}_{3} \text{OH} \text{CH}_{3} \text{H}_{2} \text{O} \text{[reaction]} \text{product?} \]

(a) \[ \text{[structure]} \]  
(b) \[ \text{[structure]} \]  
(c) \[ \text{[structure]} \]  
(d) \[ \text{[structure]} \]  
(e) none of the above
58. What is the Lewis structure of HNO₃?

(a) 

(b) 

(c) 

(d) 

(e) none of the above

Answer questions 59 - 60 based on the step-by-step mechanism of the following Friedel-Crafts alkylation:

\[ \text{Cl} + \text{AlCl}_3 \rightarrow \text{+} + \text{AlCl}_4^- \]

\[ \text{OCH}_3 + \text{step 1} \rightarrow \text{OCH}_3 \]

\[ \text{step 2} \]

59. What's the role of AlCl₃ in this reaction?

(a) Solvent  
(b) Nucleophile  
(c) Catalyst  
(d) Leaving group  
(e) None of the above

60. Which step is the rate-determining step?

(a) Step 1  
(b) Step 2  
(c) Steps 1 or 2; depend on the activation of benzene  
(d) Steps 1 and 2 are both rate-determining  
(e) None of the above

Continue to the next page
II. Use the following table and provide the Lewis structures for the following compounds in designated cells. Assign formal charges as appropriate. No partial point will be awarded for misplaced answer. (10 points)

(A) C₂H₂, (B) CH₃CO₂CH₃, (C) CH₂N₂, (D) CH₃CONH₂, (E) HN₃

<table>
<thead>
<tr>
<th>A:</th>
<th>B:</th>
<th>C:</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>D:</th>
<th>E:</th>
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</tbody>
</table>
III. Transamination catalyzed by aminotransferase is an important class of enzyme involved in the metabolic pathway of amino acids. For example, alanine aminotransferase, which also can serve as a diagnostic test of liver function, catalyzes the transfer of amino group (NH₂) from alanine to α-ketoglutarate.

\[
\text{alanine} + \text{α-ketoglutarate} \xrightarrow{\text{alanine aminotransferase}} \text{pyruvate} + \text{glutamate}
\]

The process involves the formation of imine (Schiff base) between alanine and pyridoxal phosphate (PLP), as known as vitamin B6.

\[
\text{Alanine} + \text{PLP} \xrightleftharpoons{} \text{Imine (Schiff base) intermediate}
\]

Use the simplified structures below to represent alanine and PLP and propose an electron-pushing mechanism for the formation of imine intermediate. (10 points)

\[
\text{Alanine} + \text{PLP} \xrightarrow{} \text{imine intermediate}
\]
Next Pages: Periodic Table, pKa, and pKb Values
pKₐ Values for Some organic and Inorganic Acids

<table>
<thead>
<tr>
<th>Acid</th>
<th>Formula</th>
<th>pKₐ</th>
<th>Conjugate Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethane</td>
<td>CH₃CH₃</td>
<td>51</td>
<td>CH₃CH₂⁻</td>
</tr>
<tr>
<td>Ammonia</td>
<td>NH₃</td>
<td>38</td>
<td>NH₂⁻</td>
</tr>
<tr>
<td>Ethanol</td>
<td>CH₃CH₂OH</td>
<td>15.9</td>
<td>CH₃CH₂O⁻</td>
</tr>
<tr>
<td>Water</td>
<td>H₂O</td>
<td>15.7</td>
<td>HO⁻</td>
</tr>
<tr>
<td>Ethylammonium ion</td>
<td>CH₃CH₂NH₃⁺</td>
<td>10.64</td>
<td>CH₃CH₂NH₂⁺</td>
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<tr>
<td>Bicarbonate ion</td>
<td>HCO₃⁻</td>
<td>10.33</td>
<td>CO₃²⁻</td>
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<tr>
<td>Phenol</td>
<td>C₆H₅OH</td>
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<td>C₆H₅O⁻</td>
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<td>Ammonium ion</td>
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<td>9.24</td>
<td>NH₃</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>H₂CO₃</td>
<td>6.36</td>
<td>HCO₃⁻</td>
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<tr>
<td>Acetic acid</td>
<td>CH₃CO₂H</td>
<td>4.76</td>
<td>CH₃CO₂⁻</td>
</tr>
<tr>
<td>Benzoic acid</td>
<td>C₆H₅CO₂H</td>
<td>4.19</td>
<td>C₆H₅CO₂⁻</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>H₃PO₄</td>
<td>2.1</td>
<td>H₂PO₄⁻</td>
</tr>
<tr>
<td>Hydronium ion</td>
<td>H₃O⁺</td>
<td>-1.74</td>
<td>H₂O</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>H₂SO₄</td>
<td>-5.2</td>
<td>HSO₄⁻</td>
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<td>Hydrogen chloride</td>
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<td>-7</td>
<td>Cl⁻</td>
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<tr>
<td>Hydrogen bromide</td>
<td>HBr</td>
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</tr>
<tr>
<td>Hydrogen iodide</td>
<td>HI</td>
<td>-9</td>
<td>I⁻</td>
</tr>
</tbody>
</table>
### pKb Values for Selected Amines and pKa Values for Their Conjugate Acids

<table>
<thead>
<tr>
<th>Amine</th>
<th>Formula/Structure</th>
<th>pKb</th>
<th>Conjugate Acid</th>
<th>pKa</th>
</tr>
</thead>
<tbody>
<tr>
<td>methylamine</td>
<td>CH₃NH₂</td>
<td>3.36</td>
<td>CH₃NH₃⁺</td>
<td>10.64</td>
</tr>
<tr>
<td>ethylamine</td>
<td>CH₃CH₂NH₂</td>
<td>3.19</td>
<td>CH₃CH₂NH₃⁺</td>
<td>10.81</td>
</tr>
<tr>
<td>dimethylamine</td>
<td>(CH₃)₂NH</td>
<td>3.27</td>
<td>(CH₃)₂NH₂⁺</td>
<td>10.73</td>
</tr>
<tr>
<td>diethyleamine</td>
<td>(CH₃CH₂)₂NH</td>
<td>3.02</td>
<td>(CH₃CH₂)₂NH₂⁺</td>
<td>10.98</td>
</tr>
<tr>
<td>trimethylamine</td>
<td>(CH₃)₃N</td>
<td>4.19</td>
<td>(CH₃)₂NH⁺</td>
<td>9.81</td>
</tr>
<tr>
<td>triethyleamine</td>
<td>(CH₃CH₂)₃N</td>
<td>3.25</td>
<td>(CH₃CH₂)₃NH⁺</td>
<td>10.75</td>
</tr>
<tr>
<td>aniline</td>
<td><img src="image" alt="Aniline Structure" /></td>
<td>9.37</td>
<td><img src="image" alt="Aniline Structure" /></td>
<td>4.63</td>
</tr>
<tr>
<td>4-methylaniline</td>
<td><img src="image" alt="4-Methylaniline Structure" /></td>
<td>8.92</td>
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<td>5.08</td>
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<tr>
<td>4-chloroaniline</td>
<td><img src="image" alt="4-Chloroaniline Structure" /></td>
<td>9.85</td>
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<td>4.15</td>
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<tr>
<td>4-nitroaniline</td>
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<td>13.0</td>
<td><img src="image" alt="4-Nitroaniline Structure" /></td>
<td>1.0</td>
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<tr>
<td>pyridine</td>
<td><img src="image" alt="Pyridine Structure" /></td>
<td>8.75</td>
<td><img src="image" alt="Pyridine Structure" /></td>
<td>5.25</td>
</tr>
<tr>
<td>imidazole</td>
<td><img src="image" alt="Imidazole Structure" /></td>
<td>7.05</td>
<td><img src="image" alt="Imidazole Structure" /></td>
<td>6.95</td>
</tr>
</tbody>
</table>

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