PHARMACEUTICAL CHEMISTRY
EXAM #1
February 19, 2009

Name

SECTION B. Answer each question in this section by writing the letter corresponding to the best answer on the line provided (2 points each; 60 points total) USE THE REVERSE SIDE OF YOUR SCANTRON SHEET TO ANSWER QUESTIONS IN SECTION B.

1. The compound shown below:

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Has three double bonds with (E)-stereochemistry</td>
<td>Contains an enol functional group</td>
<td>Has two double bonds with (Z)-stereochemistry and one double bond with (E)-stereochemistry</td>
</tr>
</tbody>
</table>

a) I only
b) III only
c) I and II only
d) II and III only
e) I, II, and III

Answer

2. The compound illustrated below:

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Has one basic site with pKb = 3</td>
<td>Contains an imine functional group</td>
<td>Has one basic site with pKb = 10</td>
</tr>
</tbody>
</table>

a) I only
b) III only
c) I and II only
d) II and III only
e) I, II, and III

Answer

3. For the structures illustrated below:

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compound A has a larger log P than compound B</td>
<td>Compound B is a stronger acid than compound A</td>
<td>Compounds A and B will both behave as bases</td>
</tr>
</tbody>
</table>

a) I only
b) III only
c) I and II only
d) II and III only
e) I, II, and III

Answer
4. The compound illustrated below:

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Is planar</td>
<td>Is 50% ionized at pH 4</td>
<td>Is aromatic</td>
</tr>
</tbody>
</table>

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**

5. For the structures illustrated below:

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**

6. The compound shown below:

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contains two trans-fused six-membered rings</td>
<td>Has a methyl group that is axial</td>
<td>Contains an alcohol functional group</td>
</tr>
</tbody>
</table>

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**

7. For the structures illustrated below:

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**
8. The compound illustrated below:

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Is completely planar</td>
<td>Contains an imine functional group</td>
<td>Contains an amine functional group</td>
</tr>
</tbody>
</table>

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

Answer

9. The compound illustrated below:

I Has methyl groups that are cis-to one another  
II Is shown as its lowest energy conformation  
III Has the methyl group with the asterisk (*) trans to the alcohol group

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

Answer

10. Consider the two structures shown below:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Structures A and B are enantiomers</td>
<td>Structures A and B are diastereomers</td>
</tr>
<tr>
<td>II</td>
<td>The stereochemistry at the chiral center containing the aldehyde group is the same for both A and B</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Structures A and B are diastereomers</td>
<td></td>
</tr>
</tbody>
</table>

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

Answer

11. The compound shown below:

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Is a strong base</td>
<td>Has a conjugate acid with pK_a = 13</td>
<td>Contains an amidine functional group</td>
</tr>
</tbody>
</table>

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

Answer
12. **The compound illustrated below:**

![Compound Image]

- I: Has an amine group with $pK_b = 10$
- II: Has an exocyclic double bond with (E)-stereochemistry
- III: Has an amine group with $pK_b = 5$

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**

13. **The compound illustrated below:**

![Compound Image]

- I: Contains a carbamate functional group
- II: Contains a sulfide functional group
- III: Has two chiral centers with the (S)-configuration

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**

14. **The compound illustrated below:**

![Compound Image]

- I: Contains two nitrogens that behave as bases
- II: Has a conjugate acid with $pK_a = 4$
- III: Is aromatic

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**

15. **In the structure illustrated below:**

![Compound Image]

- I: There is a lactone functional group
- II: There are two nitrogens that behave as bases
- III: There is one neutral nitrogen and one weakly acidic nitrogen

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**
16. **In the compound illustrated below:**

![Image of a compound with a circled methyl group and oxygen atoms.]

- I The methyl group that is circled is Pro-S
- II The hybridization of the oxygen in the ring is sp³
- III The methyl group that is circled is Pro-R

a) I only
b) III only
c) I and II only
d) II and III only
e) I, II, and III

**Answer**

17. **For the structures illustrated below:**

![Image of two compounds, A and B, with a nitrogen atom and various functional groups.]

- I Compound B will have a lower log P than compound A
- II Compound B will have a lower pKₐ than compound A
- III Compound B will have a larger Kₐ than compound A

a) I only
b) III only
c) I and II only
d) II and III only
e) I, II, and III

**Answer**

18. **For the two compounds illustrated below:**

![Image of two compounds, A and B, with hydroxyl groups.]

- I Compound B is meso
- II Compound B must have the same bp as compound A
- III Compounds A and B are enantiomers

bp = 202 °C

a) I only
b) III only
c) I and II only
d) II and III only
e) I, II, and III

**Answer**

19. **The compound illustrated below:**

![Image of a complex compound with various functional groups.]

- I Contains exactly three chiral centers
- II Has [α] = 0°
- III Contains exactly two chiral centers

a) I only
b) III only
c) I and II only
d) II and III only
e) I, II, and III

**Answer**
20. Consider the structures shown below:

![Structures A and B](image)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Compound B is a resonance structure of compound A</td>
</tr>
<tr>
<td>II</td>
<td>Compound A is higher in energy than compound B</td>
</tr>
<tr>
<td>III</td>
<td>Compound A is a tautomer structure of compound B</td>
</tr>
</tbody>
</table>

a) I only  

b) III only  

c) I and II only  

d) II and III only  

e) I, II, and III  

Answer ______

21. The compound illustrated below:

![Compound](image)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Has a conjugate base with pK_b = 10</td>
</tr>
<tr>
<td>II</td>
<td>Is 100% ionized at pH 4</td>
</tr>
<tr>
<td>III</td>
<td>Is 50% ionized at pH 4</td>
</tr>
</tbody>
</table>

a) only  

b) III only  

c) I and II only  

d) II and III only  

e) I, II, and III  

Answer ______

22. The structure shown below:

![Structure](image)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Is aromatic</td>
</tr>
<tr>
<td>II</td>
<td>Uses the lone pair of electrons from the nitrogen to make the ring aromatic</td>
</tr>
<tr>
<td>III</td>
<td>Is not aromatic</td>
</tr>
</tbody>
</table>

a) I only  

b) III only  

c) I and II only  

d) II and III only  

e) I, II, and III  

Answer ______

23. For the structures shown below:

![Structures A and B](image)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>The two methyl groups of structure A are in the plane of the ring</td>
</tr>
<tr>
<td>II</td>
<td>Compound A is aromatic</td>
</tr>
<tr>
<td>III</td>
<td>Compound B is lower in energy than compound A</td>
</tr>
</tbody>
</table>

a) I only  

b) III only  

c) I and II only  

d) II and III only  

e) I, II, and III  

Answer ______
24. The compound illustrated below:

- **I** Contains a ketone
- **II** Contains a lactam
- **III** Contains a lactone

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

Answer

25. The compound illustrated below:

- **I** Is 50% ionized at pH 9
- **II** Has a conjugate acid with $pK_a = 9$
- **III** Is 50% ionized at pH 14

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

Answer

26. The compound illustrated below:

- **I** Has two chlorines that are *gauche* with respect to one another
- **II** Is shown in its lowest energy conformation
- **III** Has two chlorines that are *anti* - with respect to one another

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

Answer

27. For the compound illustrated below:

- **I** The lone pair of electrons on the nitrogen is in the plane of the ring
- **II** The ring is aromatic
- **III** The $pK_b = 10$

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

Answer
28. **For the compounds illustrated below:**

<table>
<thead>
<tr>
<th>Compound</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{H}_3\text{C} \text{N} \text{C} \text{H}_3 \text{O} \text{N} \text{C} \text{H}_3 )</td>
<td>( \text{H}_3\text{C} \text{N} \text{C} \text{H}_3 \text{O} \text{N} \text{C} \text{H}_3 )</td>
<td></td>
</tr>
</tbody>
</table>

I Compound A has a smaller \( K_a \) than compound B  
II Compound B has a smaller \( pK_a \) than compound A  
III Compound B is a stronger acid than compound A

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**

29. **In the compound illustrated below:**

<table>
<thead>
<tr>
<th>( \text{O} \text{C} \text{O} )</th>
<th>( \text{O} \text{C} \text{O} )</th>
</tr>
</thead>
</table>

I There are two ketones and one ether  
II The two carbonyl groups are in perpendicular planes  
III There is one chiral center with \( (R) \)-stereochemistry

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**

30. **For the compounds illustrated below:**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{H} \text{C} \text{N} \text{H} \text{C} \text{H}_2 \text{Cl} )</td>
<td>( \text{H} \text{C} \text{N} \text{H} \text{C} \text{H}_2 \text{Cl} )</td>
</tr>
</tbody>
</table>

I The conjugate acid of compound A has a smaller \( pK_a \) than the conjugate acid of compound B  
II Compound A is a stronger base than compound B  
III The chlorine in compound A is in conjugation with the amine group

a) I only  
b) III only  
c) I and II only  
d) II and III only  
e) I, II, and III

**Answer**
SECTION C. 9 Points Total.

The compound on the left below is the sugar allose. It has an optical rotation $[\alpha] = +15^\circ$. Write the stereochemistry (R or S) at each chiral center of allose. Then answer the questions below.

![Allose and Compound B](image)

1. What is the relationship (enantiomer, diastereomer, or same compound) of Compound B to the allose structure shown above?

2. Would the optical rotation of Compound B be: $+15^\circ$, $-15^\circ$, $0^\circ$, or is there not enough information to determine it?

3. Is the allose structure shown above the D- or L-enantiomer?

4. If the aldehyde group (CHO) of allose was subjected to chemical reduction to a primary alcohol (CH$_2$OH) what would be the optical rotation of the product in degrees?

5. Explain your answer from question 4.
SECTION D. For each of the following pairs of compounds circle the one that has the higher log P. (6 points).

a)

b)

c)

d)

e)

f)