Midterm 2 Key

Part A. Multiple Choice

1. Which is FALSE regarding the following acid-base reaction?

A) “A” is an acid and “B” is a base because B is electron rich and has the ability to donate its electrons.
B) The pKa of “B” is higher than the pKa of “A”.
C) The nitrogen on “B” will attack the hydrogen on the alcohol of “A” because they are closer in proximity to each other and thus the reaction will require less energy.
D) The nitrogen will attack the hydrogen on the carboxylic acid of “A” because it is more acidic and thus more willing to give up the hydrogen.

2. Which of the following ammonium cations have a lower pKa?

A) “A” has a lower pKa because the oxygen oxygen stabilizes the conjugate base via induction.
B) “A” has a lower pKa because the oxygen allows for resonance effect.
C) “B” has a lower pKa because there’s no oxygen stopping nitrogen from giving the hydrogen away.
D) “B” has a lower pKa because it is a more stable compound without the oxygen.
3. What are all the different functional groups in atenolol, a drug used to treat hypertension?

A) Amine, carbonyl, aromatic, ester, alcohol
B) Amide, aromatic, ether, alcohol
C) Amide, aromatic, ester, alcohol
D) Amine, aromatic, ketone, alcohol

4. Which of the following structure(s) contain a ketone?

CH₂CH₂NHCOCH₃  CH₃CH₂OCH₂CH₃  CH₃CH₂COCH₂CH₃  CH₃(CH₂)₂CHO
I          II          III          IV

A) I only               B) II and III only         C) III only               D) II, III, and IV

5. What is the relationship between the strength of an intermolecular force and the polarizability of atoms?

A) Larger atoms have a stronger intermolecular force.
B) Smaller atoms have a stronger intermolecular force.
C) Larger atoms have a weaker intermolecular force
D) There is no relationship between polarizability and intermolecular force.

6. Rank the following compounds with the highest melting point to the lowest melting point.

H—O—H  NaCl  H—Cl  \[\text{IV}\]
I          II          III

A) II > I > III > IV
B) II > III > I > IV
C) IV > III > I > II
D) III > II > I > IV
7. Rank the following compounds with the highest boiling point to the lowest boiling point.

A) I > II > IV > III  
B) I > III > IV > II  
C) I > III > II > IV  
D) II > IV > III > I

8. Which of the following compounds are soluble in H\_2O?

A)  
B)  
C)  
D)  

9. What is the IUPAC name for this compound?

A) 2,3-(di-sec-butyl)-6-methylheptane  
B) 4-(sec-butyl)-2-ethyl-3,7-dimethyloctane  
C) 5-(sec-butyl)-3,4,8-trimethylnonane  
D) 5-(sec-butyl)-2,6,7-trimethylnonane

10. What is the parent chain for this compound?

A) Hexane  
B) Cyclopentane  
C) Undecane (11 C’s)  
D) Pentane
11. Which of the following has a quaternary carbon?

A) I  
B) II  
C) III  
D) IV 

12. Which of the following is the most stable conformer of hexane?

A) I  
B) II  
C) III  
D) IV 

13. Which of the following is the highest energy conformer of this compound?

A) I  
B) II  
C) III  
D) IV 

14. Refer back to question 13. What is the reason that the answer you chose has the highest energy conformation?

A) The CHO in the back is in a gauche interaction with the CHO and CH₃ in the back, which causes steric strain.

B) The eclipsing interactions between CHO and CH₃ cause torsional strain.

C) The eclipsing interactions between the two CHO cause torsional strain.

D) The CHO are in an anti conformation so they have higher energy due to the stability.
15. What is the relationship between the following compounds?

![Chemical Structures](image)

A) Enantiomers  **B) Diastereomers**  C) Identical  D) Constitutional isomers

16. What is the correct R and S configuration of the stereogenic centers?

![Chemical Structure](image)

A) OH: R; Cl: S; CH\_2CH\_3: R  C) OH: S; Cl: R; CH\_2CH\_3: R
B) OH: R; Cl: R; CH\_2CH\_3: S  **D) OH: R; Cl: S; CH\_2CH\_3: S**

17. Which of the molecules are achiral?

![Chemical Structures](image)

A) I only  B) II and IV  **C) I and III**  D) I and IV

18. What is the relationship between the following compounds?

![Chemical Structures](image)

A) Diastereomers  **B) Enantiomers**  C) Identical  D) Trans
19. What is the correct R and S configuration of the stereogenic centers and what are the relationships between these two compounds?

![Chemical structures]

A) S and R, enantiomers
B) R and S, enantiomers
C) S and R, diastereomers
D) R and S, diastereomers

20. Which of the following compounds are possible chair conformations for the following compound?

![Chemical structures]

A) I and IV  B) II and III  C) II only  D) III only
Part B. Short Answers

1. Oseltamivir is an antiviral drug used to treat symptoms caused by the influenza. It inhibits the neuraminidase enzyme to prevent the flu virus from spreading.

![Chemical Structure of Oseltamivir](image)

a) Identify all the chiral centers and label each one as either (S) or (R) configuration. Show your work for full credit.

- A = (S) → H is in front
- B = (S) → H is in back
- C = (R) → H is in front

1 = O, 2 = C-N, 3 = C=C
1 = N, 2 = C-O, 3 = C-N
1 = N, 2 = C-N, 3 = C-C

b) How many stereoisomers of oseltamivir are possible?

2³ = 8

c) Identify all the functional groups in oseltamivir.

- amide, amine, alkene, ester

d) Which hydrogen is the most acidic? Which atom is the most basic?

- H on the amide is most acidic, N on the amine is most basic

e) Ying attempts to synthesize oseltamivir in her lab, but ends up making its enantiomer instead. Draw the molecule that she made.

![Chemical Structure of Enantiomer](image)
2. The following is a treatment of an alkene with hydrobromic acid to form an alkyl bromide. Answer questions about the reaction below.

\[
\begin{align*}
A + HBr & \rightarrow C \\
\text{Alkene} + \text{HBr} & \rightarrow \text{Alkyl bromide}
\end{align*}
\]

a) What is the IUPAC name for the compound C that is formed?
1-bromo-4-methylcyclohexane

b) Draw the two chair conformations of C with both substituents trans to each other on the templates below.

\[
\begin{align*}
\text{Conformation 1} & \quad \leftrightarrow \quad \text{Conformation 2}
\end{align*}
\]

c) Circle the conformation above that you predict to be more stable and explain why.
The substituents are both equatorial to avoid steric strain (1-3 diaxial interactions)

d) Draw a chiral constitutional isomer of compound C.

\[
\begin{align*}
\text{Chiral Isomer 1} & \quad \text{Chiral Isomer 2} & \quad \text{Chiral Isomer 3} & \quad \text{Chiral Isomer 4}
\end{align*}
\]

e) Ying thinks the alkyl bromide formed from the reaction is achiral, while Anh says it is also meso. Who is right and why?
Ying is right because an achiral molecule is identical to its enantiomer (superimposable) and have a plane of symmetry. However, a meso compound has stereocenters but is achiral. This alkyl bromide is only achiral and not meso, as it does not have any stereocenters.
3. Answer the following questions about the Newman projections below.

![Newman projections]

a) Label each Newman projection with the terms *eclipsed, staggered, anti, gauche* appropriately.

b) Another conformation exists at different energy level compared to the above conformations. Draw what it looks like and explain why it is lower/higher in energy relative to the above conformations.

The staggered anti conformation places the biggest groups 180° from each other, giving it less steric strain than the other two conformations. Thus, it is lower in energy and the most stable conformation.

c) Using the Newman projections above, draw all possible stereoisomers of this molecule. Then label the relationships between the stereoisomers (enantiomer/diastereomer).

d) If Anh performed a reaction with this molecule and added more functional groups to it, what would happen to the boiling point of the new product?

Adding more functional groups = make it more polar due to dipole dipole interactions → stronger than van der Waals → stronger bonds are harder to break → boiling point increases
4. Cyclopentanecarboxylic acid reacts with methanamine to form the carboxylate below. Answer questions about this acid/base reaction.

\[
\begin{array}{c}
\text{Cyclopentanecarboxylic acid} + \text{Methanamine} \\
\xrightarrow{\text{Forward Reaction}} \\
\text{Carboxylate}
\end{array}
\]

a) Draw curved arrows to show how the forward reaction occurs above.

b) Draw all possible stereoisomers for the carboxylic acid above.

c) The stockroom ran out of carboxylic acid, so Ying tries to make some more for her experiment. The mixture had an observed specific rotation of +10°. Ying only wants the (R,S) enantiomer, which has a specific rotation of -40°. What is the enantiomeric excess of the (S,R) enantiomer?

\[
\% \text{ ee} = \frac{\text{specific rotation of mixture}}{\text{specific rotation of pure enantiomer}} \times 100%
\]

\[
\% \text{ ee} = \frac{10}{40} \times 100\% = 25\% \text{ ee}
\]

d) Determine the percentage of each isomer in the mixture.

\[
\text{[R,S] enantiomer} + \text{[S,R] enantiomer} = 100\%
\]

\[
[x] + [x + 25] = 100
\]

\[
x = 37.5
\]

(R,S) enantiomer = 37.5%
(S,R) enantiomer = 37.5 + 25 = 62.5%

e) Anh tries to make some carboxylic acid products for Ying, and she thinks her mixture is now pure since it has an optical rotation of 0°. Why is Ying still not satisfied?

A racemic mixture has an optical rotation of zero because it has equal amounts of both enantiomers. This means there is 50% of one isomer and 50% of its enantiomer, but Ying wants an enantiomerically pure sample.