

Exam Booklet No.

CHEM 2410 – Organic Chemistry 1 – Fall 2016

Instructors: Paul Bracher & Erin Witteck

Hour Examination #1

Wednesday, September 14th, 2016

6:10–8:10 p.m. in the Lecture Halls at Saint Louis University

Student Name (Printed)	Solutions
Student Signature	N/A

Instructions & Scoring

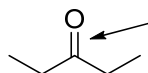
- Please write your answers on the official answer sheet. No answers marked in this booklet will be graded.
- You may use one letter-sized sheet of hand-written notes (on the “official” template) and your plastic model kit. No electronic resources are permitted and you may not communicate with others.
- Your exam answer sheet may be copied or scanned.
- The examination room may be photographed or videotaped.

Problem	Points Earned	Points Available
I		60
II		10
III		10
IV		10
V		10
TOTAL		100

Questions, **Required Information**, **Supplementary Information**

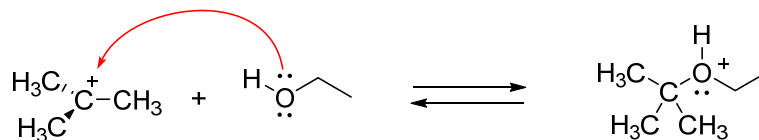
Problem I. Multiple choice (60 points total; +3 points for a correct answer, +1 points for answering with the letter “E”, and 0 points for an incorrect answer). For each question, select the most correct and complete answer of the choices given. Bubble the answer, darkly, in the space provided on the answer sheet.

- (1) C What orbitals form the connection between the central carbon atom and oxygen atom in 3-pentanone (**A**)?

**A**

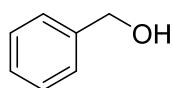
- (A) two sp^2 orbitals
 (B) one sp^2 orbital and one sp^3 orbital
 (C) two sp^2 orbitals and two p orbitals
 (D) one sp^2 orbital, one sp^3 orbital, and two p orbitals

- (2) A Which of the following statements regarding the reaction drawn below is correct?

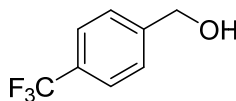


- (A) the hybridization of the oxygen atom is sp^3 in the reactant and product
 (B) the curved arrow is wrong—it should point toward the oxygen atom
 (C) the alcohol reacts as a Lewis base and electrophile
 (D) the oxygen atom in the product should not have a +1 formal charge

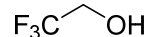
- (3) C Which of the following compounds is the strongest Brønsted–Lowry acid?



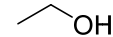
(A)



(B)

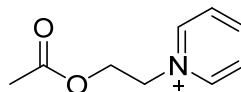


(C)



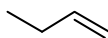
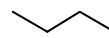
(D)

- (4) C How many non-bonding (lone) electron pairs should be drawn in the Lewis structure for compound **B**?

**B**

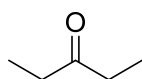
- (A) two
(B) three
(C) four
(D) five

- (5) A Which of the following statements best describes the relative Brønsted–Lowry acidity and basicity of compounds **C** and **D**?

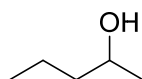
**C****D**

- (A) compound **C** is the stronger acid and the stronger base
(B) compound **D** is the stronger acid and the stronger base
(C) compound **C** is the stronger acid, compound **D** is the stronger base
(D) compound **D** is the stronger acid, compound **C** is the stronger base

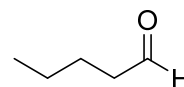
- (6) B Which of the following compounds has the highest boiling point?



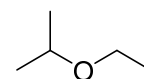
(A)



(B)

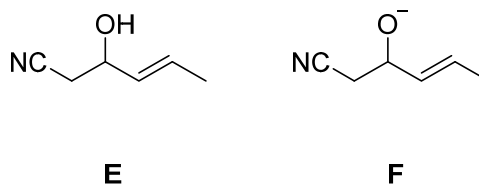


(C)



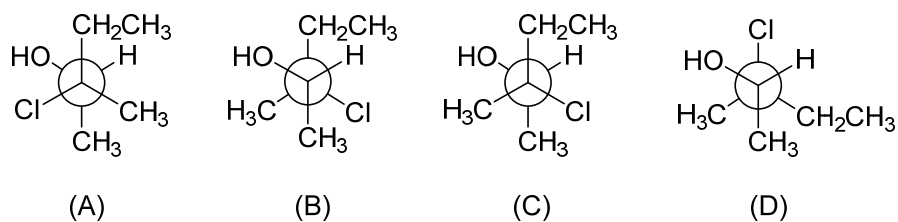
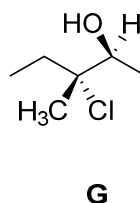
(D)

(7) D What statement is not true regarding compounds E and F?



- (A) compound E has two *sp*-hybridized atoms
- (B) compound E has nine hydrogen atoms
- (C) F is the conjugate base of compound E
- (D) the extra charge on F is stabilized by a resonance effect

(8) B Which of the following Newman projections is an accurate representation of compound G?

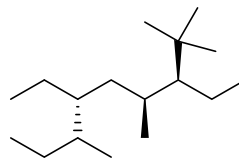


(9) C How many different isomers of C₅H₈ are alkynes?

- (A) one
- (B) two
- (C) three
- (D) four

(10) D

Which of the following locant numbers does not appear in the IUPAC name for compound **H**?

**H**

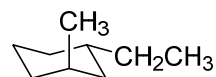
- (A) 2
 (B) 3
 (C) 4
 (D) none of the above (i.e., these numbers all appear in the name of **H**)

(11) B

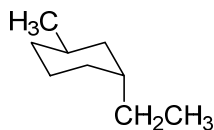
Which of the following structures represents the most stable conformation of *trans*-1-ethyl-3-methylcyclohexane?



(A)



(B)

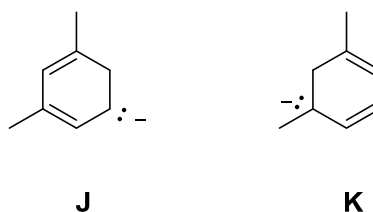


(C)



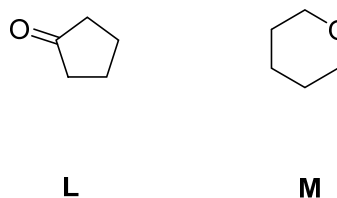
(D)

(12) ^B What term best describes the relationship of structures **J** and **K**?



- (A) resonance forms
- (B) constitutional isomers
- (C) conformational isomers
- (D) steric pairs

(13) ^A What choice best and most completely describes the relationship of compounds **L** and **M**?

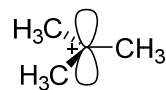
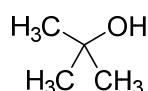


- (A) **L** is a stronger acid than **M**
- (B) **L** and **M** are resonance forms
- (C) **L** and **M** are constitutional isomers
- (D) statements (A) and (C) are both true

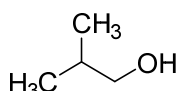
(14) ^D When a small sample of *o*-chlorophenol ($pK_a = 8.6$) is dissolved in an aqueous solution buffered at pH 6.6, what is the approximate ratio of the concentration of *o*-chlorophenol to its conjugate base (i.e., [*o*-chlorophenol] to [*o*-chlorophenolate])?

- (A) 1 to 100 (favoring the conjugate base)
- (B) 1 to 10 (favoring the conjugate base)
- (C) 1 to 1
- (D) 100 to 1 (favoring the *o*-chlorophenol)

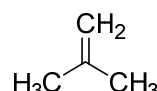
- (15) ^C Which of the following compounds is formed when hydroxide (^-OH) reacts as a Brønsted–Lowry base with trimethylcarbenium cation (**N**)?

**N**

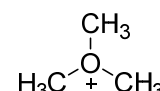
(A)



(B)

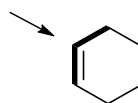


(C)



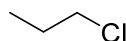
(D)

- (16) ^C What is the approximate value of the bolded C–C–C bond angle in cyclohexene (**P**)?

**P**

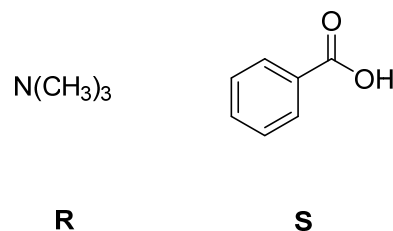
- (A) 90°
 (B) 109.5°
 (C) 120°
 (D) 180°

- (17) ^B What statement is not true regarding 1-chloropropane (**Q**)?

**Q**

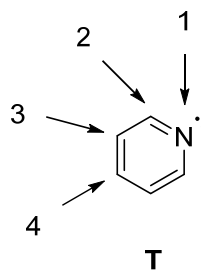
- (A) **Q** has a larger dipole moment than propane
 (B) **Q** has a higher pK_a than propane
 (C) **Q** has a higher boiling point than propane
 (D) **Q** is more oxidized than propane

- (18) A Which of the following choices represents the best method to remove trimethylamine (**R**) from a solution of benzoic acid (**S**), trimethylamine, and benzene (C₆H₆) in the solvent cyclohexane?



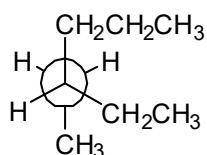
- (A) extract with aqueous 2 M HCl (pH < 1)
(B) extract with aqueous saturated NaHCO₃ (pH ≈ 8)
(C) extract with aqueous 2 M NaOH (pH > 13)
(D) extract with a non-polar organic solvent, like CCl₄

- (19) C When pyridine (**T**) is protonated by an acid, to which of the four labeled atoms is the positive charge least distributed?

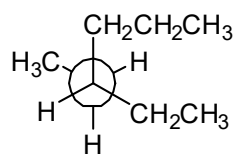


- (A) the nitrogen atom at position 1
(B) the carbon atom at position 2
(C) the carbon atom at position 3
(D) the carbon atom at position 4

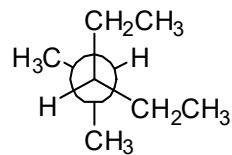
- (20) C Which of the following Newman projections represents the most stable conformation of 3-ethyl-2-methylpentane?



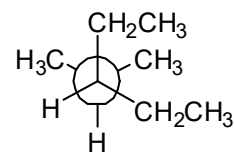
(A)



(B)

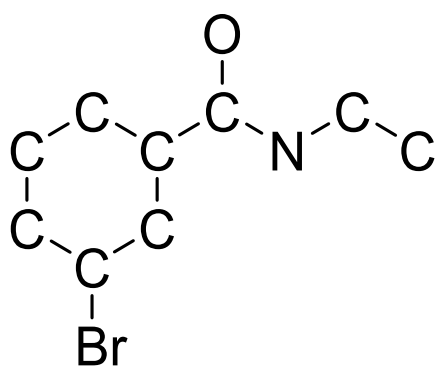


(C)

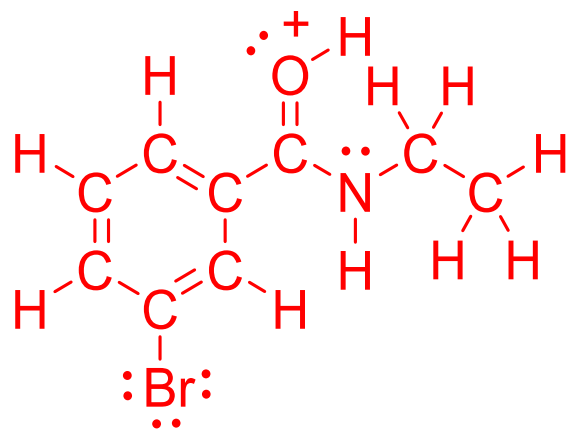


(D)

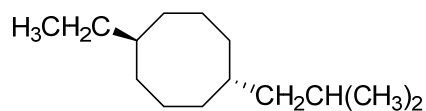
Problem II. Lewis Structure (10 points). Complete the Lewis structure for the conjugate acid of *N*-ethyl-3-bromobenzamide (**U**) that has been started on your answer sheet. The compound has the molecular formula $C_9H_{11}BrNO^+$. The structure includes an aromatic ring, an alkyl group, and a protonated amide group. All atoms in the structure (aside from hydrogen) have full octets. A formal charge appears on the most electronegative element in the molecule. Explicitly include—i.e., draw out—all hydrogens, bonding pairs, lone pairs, and non-zero formal charges on your Lewis structure.



U



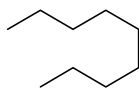
Problem III. Alkanes and Substituted Alkanes (10 points). Provide the IUPAC name for compound **V**.



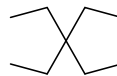
V

trans-1-ethyl-5-isobutylcyclooctane

Problem IV. Explanation (10 points). Of compounds **W** and **X**, which has the higher boiling point? Write the letter of your answer in the box on the answer sheet and provide a brief explanation (of no more than four sentences) for your choice. Answers of more than four sentences will not receive credit.



W

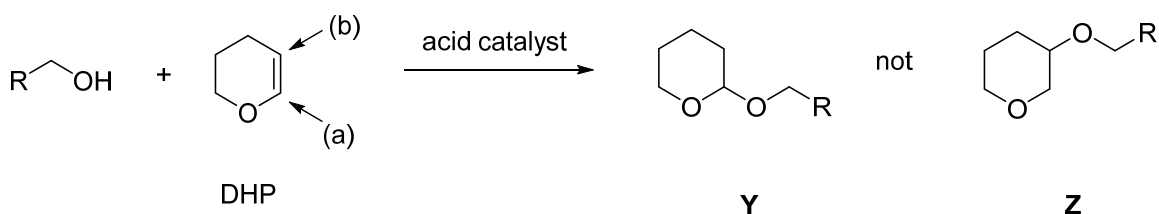


X

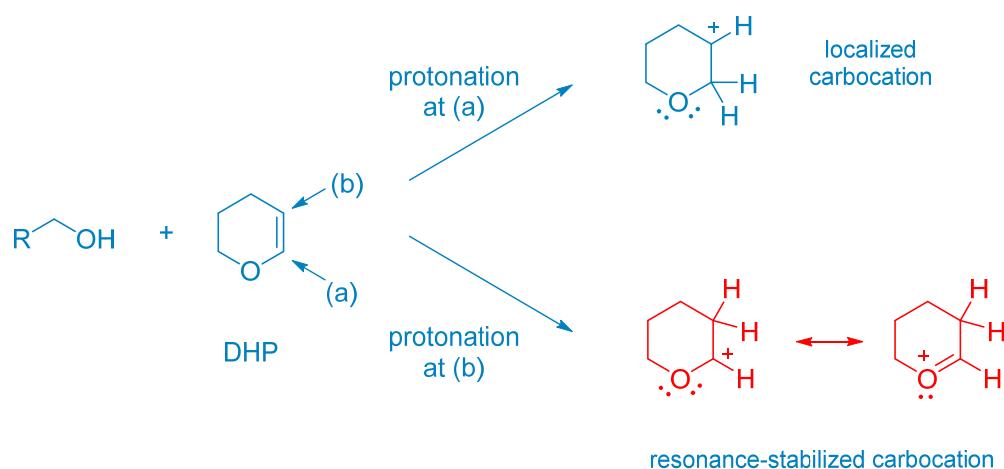
Written in box: Compound **W**.

Higher boiling points are typically associated with compounds that participate in stronger intermolecular interactions. While both **W** and **X** are isomers (with identical mass) and similar functional groups, compound **W** is less branched and, correspondingly, has an electron cloud with greater surface area. This feature leads to the net induction of stronger London forces in samples of **W**, leading to a higher boiling point than for the more compact isomer, **X**.

Problem V. Explanation (10 points). Alcohols will react with DHP in the presence of an acid catalyst to form compounds of the general structure **Y**. The isomer **Z** is not observed, because protonation of the double bond in DHP overwhelmingly favors addition of the proton to position (b) rather than position (a). Explain this preference for the protonation of DHP using drawings in your explanation. Answers of more than three sentences will not receive credit.



You are given the experimental fact that the carbon at position (b) is a stronger Brønsted–Lowry base than the carbon at position (a). We most commonly explain relative basicity by examining the relative stability of the conjugate acids. (Note that several hydrogens and lone pairs have been labeled explicitly for emphasis.)



The above scheme shows that protonation at carbon (a) leads to a relatively unfavorable localized carbocation, while protonation at carbon (b) leads to a carbocation stabilized by a resonance effect. The more-stable conjugate acid is the species more likely to form, so protonation is favored at position (b).