CHEM 2430 – Organic Chemistry I – Fall 2015

Instructor: Paul Bracher

Quiz #2

Due: Monday, September 14th, 2015

1:10 p.m. (in class)

Student Name (Printed)	Solutions
Student Signature	N/A

Instructions & Scoring

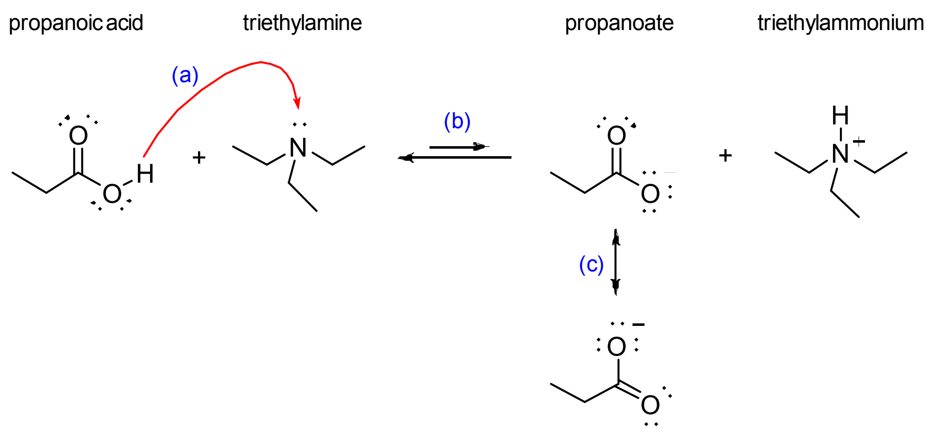
- Please write your answers on the official answer sheet. No answers marked in this booklet will be graded. Submissions submitted electronically will not be graded.
- You may use any resources you wish and collaborate with others.
- Any questions should be posted to the Blackboard discussion board so all students have equal access to the information.
- Your quiz answer sheet may be photocopied.

Problem	Points Earned	Points Available
I		30
II		20
III		10
IV		10
V		30
TOTAL		100

Questions, Required Information, Supplementary Information

Problem I. Multiple choice (30 points total; +5 points for a correct answer, +2 points for an answer intentionally left blank, and 0 points for an incorrect answer). For each question, select the best answer of the choices given. Write the answer, legibly, in the space provided on the answer sheet.

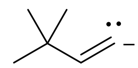
(1) ___D___ Which of the following statements best describes the use of the arrows labeled (a), (b), and (c) in the acid–base reaction depicted below?



(a) arrow (a) is used incorrectly
(b) arrows (b) are used incorrectly
(c) arrow (c) is used incorrectly
(d) arrows (a) and (b) are used incorrectly
(e) arrows (a), (b), and (c) are all used incorrectly

Arrow (a) is used incorrectly because the arrow should point from the nucleophile (Lewis base) to the electrophile (Lewis acid). The equilibrium arrows (b) are used incorrectly because this equilibrium favors the right side—not the left—as the pK_a of propionic acid is lower than the pK_a of triethylammonium. The resonance arrows (c) are used correctly.

(2) C Which of the following statements is <u>not</u> true of the anion represented by structure **A**.

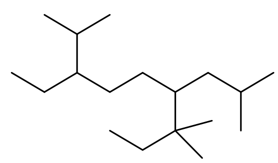


A

(a) anion **A** has 11 hydrogen atoms
(b) anion **A** would react with a weak acid to form an alkene
(c) anion **A** has one *sp*-hybridized carbon atom
(d) anion **A** has four sp^3-hybridzed carbon atoms
(e) anion **A** has a quaternary carbon atom

A more complete Lewis structure of **A** is…(continue)

(3) B What is the systematic name of compound **B**?

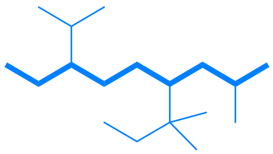


B

(a) 4-isopentyl-7-isopropyl-2-methylnonane
(b) 3-ethyl-6-isobutyl-2,7,7-trimethylnonane
(c) 6-isobutyl-3-isopropyl-7,7-dimethylnonane
(d) 7-ethyl-4-isobutyl-3,3,8-trimethylnonane
(e) none of the above

The first step is to identify the longest continuous chain of carbon atoms. There are multiple candidates:

(9)



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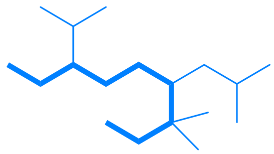
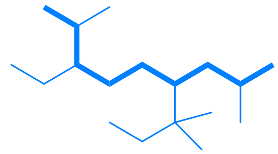
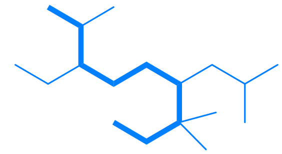


(9)

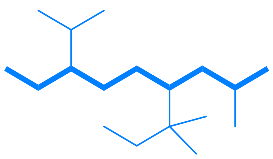


(9)

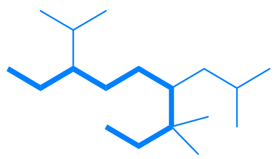


Of the longest chains, the chain that is selected as the parent is the one with the most substituent groups:

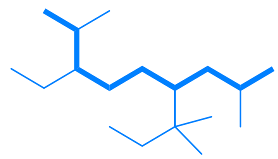
(3 substituents)



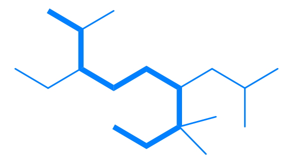
(4 substituents)



(4 substituents)



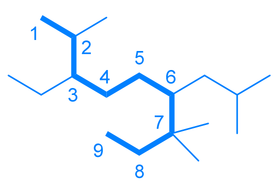
WINNER!
(5 substituents)

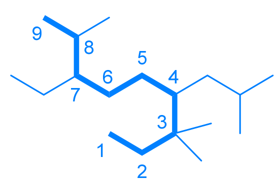


Next, you must decide from which end of the parent chain to begin numbering. This will be from the end that gives the lowest locant number to the first substituent. If there is a tie, you proceed down the line until the point of first difference.

2-methyl vs. 3,3-dimethyl

WINNER!

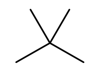




Finally, locate, name, group, and alphabetize the substituents. Remember, that most substituent prefixes (di-, tri- tetra-, penta-, *tert*-, and *sec*-) do not count for alphabetization, but some do (cyclo, iso-, neo-).

The final name of the compound is: 3-ethyl-6-isobutyl-2,7,7-trimethylnonane

(4) ___B___ Which of the following statements is <u>not</u> true of compound **C**.

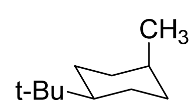


C

(a) compound **C** is named 2,2-dimethylpropane
(b) compound **C** has the lowest melting point of any isomer of C_5H_{12}
(c) compound **C** is a saturated hydrocarbon
(d) compound **C** has only sp^3-hybridized carbon atoms
(e) compound **C** is an isomer of 2-methylbutane

Compound **C** has the <u>highest</u> melting point of any isomer of C_5H_{12}.

(5) ___A___ Which of the following statements is <u>not</u> true of the molecule represented by structure **D**?



D

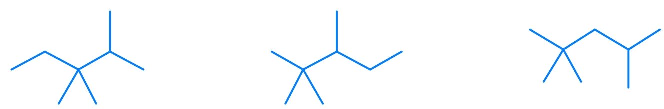
(a) the only intermolecular van der Waals forces between molecules of **D** are London forces
(b) every C–C–C bond angle in **D** is 109.5 ± 10°
(c) structure **D** represents the most stable chair conformation of the molecule
(d) the methyl group is located at the 4 position of the ring
(e) the combustion of 1 mole of **D** in an oxygen atmosphere produces 11 moles of water

Compound **D** has a non-zero dipole moment, so it will participate in dipole–dipole intermolecular interactions, although they are relatively weak.

(6) D How many hydrogen atoms are in the smallest (lowest mass), acyclic alkane that has at least one primary, one secondary, one tertiary, and one quaternary carbon?

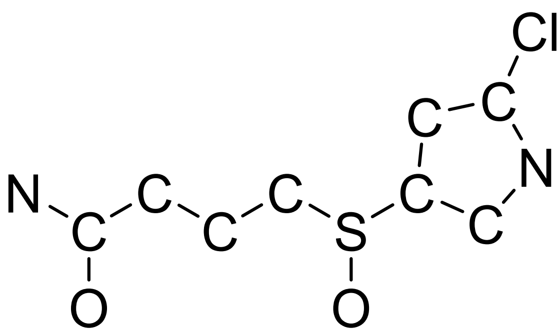
(a) 10
(b) 14
(c) 16
(d) 18
(e) 20

Possible structures include:

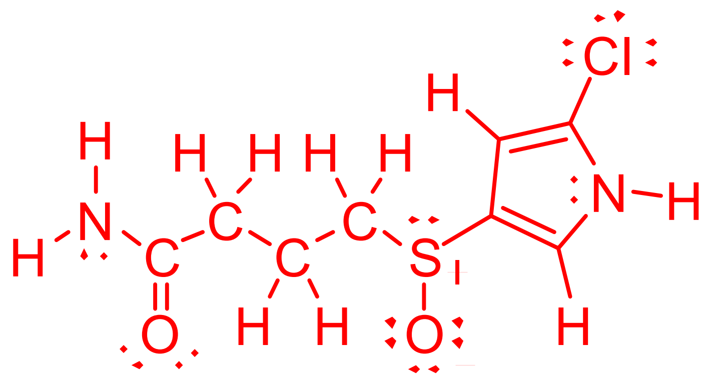


all are C_8H_{18}

Problem II. Lewis Structure (20 points). Complete the Lewis structure for compound **E**, shown below. The compound has the molecular formula $C_8H_{11}ClN_2O_2S$. The sulfur atom has a formal charge of +1, and its adjacent oxygen atom has a formal charge of -1. There are no other formal charges in the structure. All of the carbon atoms in the ring are *sp*^{2}-hybridized. Among other features, the compound has an amide functional group and a secondary amine. Explicitly include—i.e., draw out—all hydrogen atoms, bonding pairs, lone pairs, and non-zero formal charges on your Lewis structure. The molecule has been started on your answer sheet.

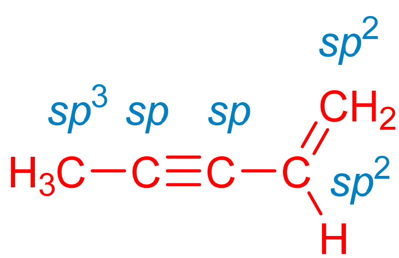


E



E

Problem III. Short Answer (10 points). Among all neutral (uncharged) hydrocarbons in which every carbon atom possesses a full octet of valence electrons, draw the structure of the smallest (by mass) compound that possesses <u>at least</u> one *sp*-hybridized carbon atom, one *sp*^{2}-hybridized carbon atom, one *sp*^{3}-hybridized carbon, one C–C single bond, one C=C double bond, and one C≡C triple bond. If there are multiple structures that meet these criteria, draw the compound with the highest pK_a. Your structure should not have any bond angles that deviate far from the ideal values for any particular hybridization of carbon.



Note that in order to make the highest possible pK_a after linking the double and triple bonds, you want to replace the proton bonded to the *sp*-hybridized carbon with the remaining methyl group.

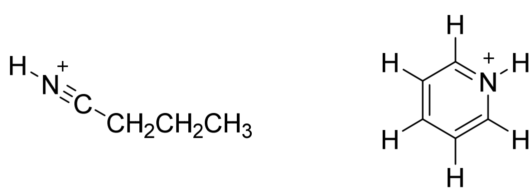
Problem IV. Isomers of Alkanes (10 points). Provide the systematic IUPAC name of the stable isomer of molecular formula $C_{10}H_{22}$ for which the sum of all the locants is the highest. That is, for all of the compounds with molecular formula $C_{10}H_{22}$, which has the name in which all of the numbers add up to the highest value? Write your answer in the box on the answer sheet.

2,2,3,4,4-pentamethylpentane

The locants for this name add up to 15. The locants for all other isomers add up to 14 or less. The best way to approach this problem is systematically. You know that you will only place methyl groups onto a parent chain because anything long is a “waste” of the available carbon atoms (you spend additional carbons without getting an additional locant).

Problem V. Explanations (30 points). For each question posed below, 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. You should draw out any relevant resonance forms if the concept factors into your explanation.

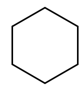
(1) (10 points) Of compounds **F** and **G**, which is the more acidic?



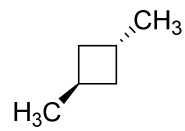
F **G**

Compound **F**. In both cases, the most acidic proton is positioned on a nitrogen atom with a positive formal charge, but the key difference is the type of orbital bearing the lone pair in the conjugate base of each acid. The lone pair is located in an *sp*-hybridized orbital for the conjugate base of **F** and an sp^2-orbital for the conjugate base of **G**. The *sp* orbital has more *s*-character and any electron density in it will be better stabilized and less available to serve as a base. Since the conjugate base of **F** is weaker, **F** must be a stronger acid.

(2) (10 points) Of compounds **H** and **J**, which has the more negative heat of combustion—i.e., for which compound is combustion more exothermic?



H



J

Compound **J**. Both compounds are isomers of C_6H_{12} and undergo complete combustion to form the same products (6 CO_2 and 6 H_2O). Since both sets of products for combustion are the same, the combustion reaction that releases more energy will be the one in which the starting material is less stable (has more potential energy to being with). In this case, **J** is significantly less stable because of angle and torsional strain in the four-membered ring, where the C–C–C bond angles significantly deviate from the ideal tetrahedral angle of 109.5° favored by sp^3-hybridized carbons.

(3) (10 points) Of compounds **K** and **L**, which has the higher boiling point?

$N(CH_3)_3$	$H_2NCH_2CH_2CH_3$
K	**L**

Compound **L**. Both compounds are isomers of C_3H_9N, but compound **L** is capable of hydrogen bonding while **K** is not. These stronger dipole–dipole intermolecular interactions lead to a higher boiling point. The less branched structure of **L**—leading to more surface area for its electron cloud and stronger London forces—probably also contributes to the higher boiling point.