CHEM 2410 – Principles of Organic Chemistry I – Summer 2016

Instructor: Paul Bracher

Hour Examination #1

Tuesday, May 31st, 2016

9:00–10:30 a.m. in Macelwane Hall 342

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 "official" paper) and your plastic model kit. No electronic resources are permitted and you may not communicate with others.
- Your exam answer sheet may be photocopied.

Problem	Points Earned	Points Available
I		60
II		10
III		14
IV		16
TOTAL		100

Questions, Required Information, Supplementary Information

Special Instructions

Please Make Sure to Do the Following Before Starting Your Exam

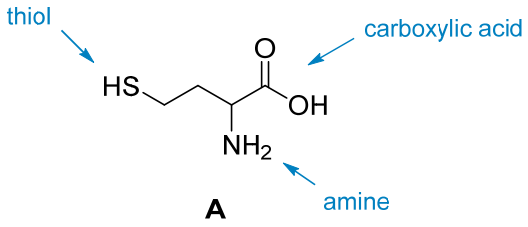
1. Both print your name and sign the front of the answer sheet in the appropriate boxes.
2. Also print your name at the top of the back of the answer sheet.
3. Enter your SLU Banner ID on the front of the answer sheet and bubble the corresponding numbers.
4. Do not check the "Hold for Pick-Up" box on the back of the answer sheet unless you want your graded sheet withheld from the distribution pile and handed back to you privately.

Please Make Sure to Do the Following After Completing Your Exam

1. Ensure that all of your selected circles are darkened completely.
2. Turn in your note sheet with your name and this exam number (#1) in the appropriate space.

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 best answer of the choices given. Write the answer, legibly, in the space provided on the answer sheet.

(1) D Which of the following functional groups is <u>not</u> present in homocysteine (**A**), a compound associated with coronary artery disease when present in elevated concentrations in blood serum?

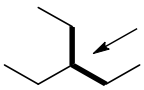


A

(A) amine
(B) thiol
(C) carboxylic acid
(D) sulfide

Compound **A** does not have a sulfide group (R–S–R') but does have the three functional groups noted above.

(2) B What is the approximate value of the bolded C–C–C bond angle (centered on C3) in 3-ethylpentane (**B**)?

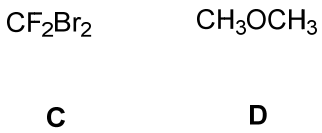


B

(A) 90°
(B) 109.5°
(C) 120°
(D) 180°

The central carbon atom (C3) is sp^3 hybridized. Thus, we expect the C–C–C bond angle to be close to 109.5°.

(3) C Which of the following statements best describes compounds **C** and **D**? The term "polar" means that a compound has a non-zero net dipole moment.



C **D**

(A) compound **C** is polar and compound **D** is not polar
(B) compound **D** is polar and compound **C** is not polar
(C) compounds **C** and **D** are both polar
(D) neither compound **C** nor **D** is polar

(4) C If a Lewis structure is drawn for carbon monoxide (CO) in which both atoms have a full octet of electrons, which statement is true of that structure?

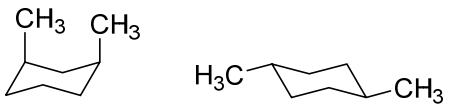
(A) neither atom bears a formal charge
(B) neither atom has a lone (nonbonding) pair
(C) neither atom is sp^2-hybridized
(D) none of the above statements is true

(5) B Which of the following anions is the strongest Brønsted–Lowry base?

(A) (B) (C) (D)

Inductive effect.

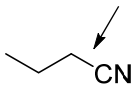
(6) B What term best describes compounds **E** and **F**?



E **F**

(A) identical
(B) constitutional isomers
(C) conformational isomers
(D) stereoisomers

(7) B What type(s) of orbitals form the bond between the C1 and C2 carbon atoms in butyronitrile (**G**)?



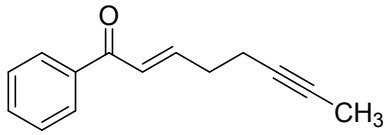
G

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

(8) A When a small sample of a pure mystery compound is dissolved in an aqueous solution buffered at pH 7, roughly 50% of the molecules in the sample lose a proton to solution. Roughly how much of the mystery compound would lose a proton if it were added to a solution buffered at pH 5?

(A) 1%
(B) 50%
(C) 99%
(D) not enough information is provided to solve this problem

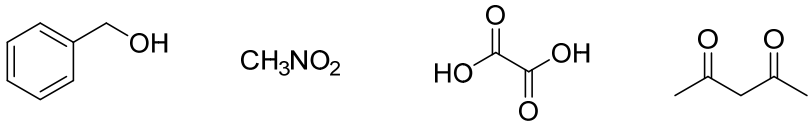
(9) D What statement is true of compound **H**?



H

(A) compound **H** has more carbon atoms than hydrogen atoms
(B) compound **H** has more hydrogen atoms than carbon atoms
(C) compound **H** has 12 electrons involved in π bonds
(D) none of the above statements is true

(10) A For which of the following organic acids is a resonance effect <u>least significant</u> in stabilizing the charge that develops on the conjugate base?



(A) (B) (C) (D)

(11) A

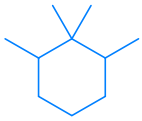
What statement is true of the most stable conformation of *cis*-1-ethyl-4-methylcyclohexane?

(A) the methyl group occupies an axial position and the ethyl group occupies an equatorial position of the ring
(B) the ethyl group occupies an axial position and the methyl group occupies an equatorial position of the ring
(C) both the methyl and ethyl groups occupy axial positions of the ring
(D) both the methyl and ethyl groups occupy equatorial positions of the ring

(12) B

How many hydrogen atoms are in the smallest (lowest mass) alkane(s), composed solely of carbon and hydrogen, with the number 6 in its proper IUPAC name?

(A) 19 or fewer hydrogen atoms
(B) 20 or 21 hydrogen atoms
(C) 22 or 23 hydrogen atoms
(D) 24 or more hydrogen atoms

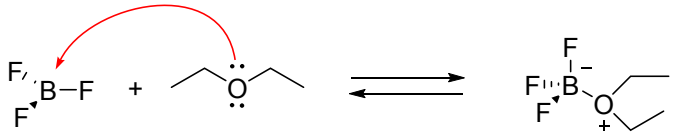


1,1,2,6-tetramethylcyclohexane
$C_{10}H_{20}$

2,6-dimethylheptane
C_9H_{20}

(13) C

Which of the following statements accurately describes the following reaction?

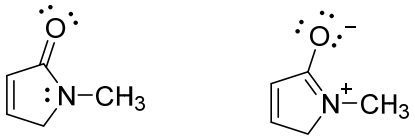


(A) boron trifluoride is a Lewis base
(B) the curved arrow is used incorrectly
(C) the hybridization of the boron atom changes during the reaction but the hybridization of the oxygen atom does not
(D) there is an unnecessary separation of formal charge shown in the structure of the product

(14) D Which of the following compounds has the highest boiling point?

(A) (B) (C) (D)

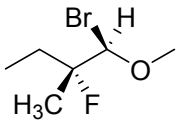
(15) A What term best describes structures **J** and **K**?



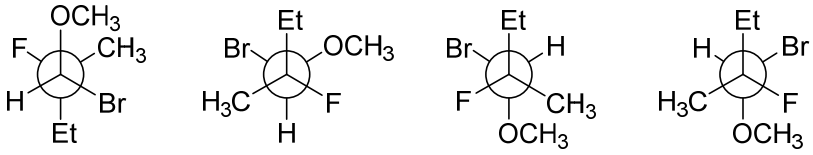
J **K**

(A) resonance forms
(B) structural isomers
(C) conformational isomers
(D) stereoisomers

(16) A Which of the following Newman projections is an accurate representation of compound **L**? "Et" is the abbreviation for an ethyl group ($-CH_2CH_3$).

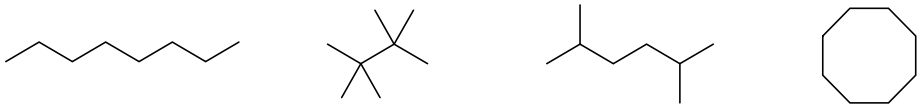


L



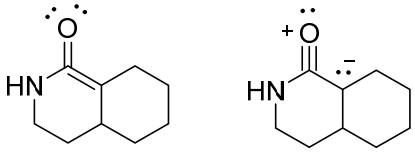
(A) (B) (C) (D)

(17) B Of all the isomers of C_8H_{18}, which compound has the shortest range of temperatures in which it exists in its liquid state?



(A) (B) (C) (D)

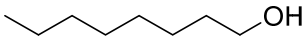
(18) D What term best describes the relationship of structures **M** and **N**?



M **N**

(A) resonance forms
(B) constitutional isomers
(C) stereoisomers
(D) both are nonsense

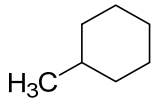
(19) D What statement most accurately and completely describes the intermolecular interactions in a sample of 1-octanol (**P**)?



P

(A) the molecules participate in hydrogen bonding
(B) the molecules participate in dipole–dipole interactions
(C) the molecules participate in London forces
(D) the molecules participate in all three of these types of interactions

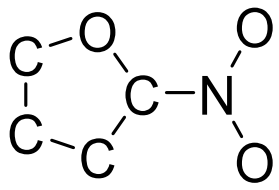
(20) B Which of the following statements is true of compound **Q**?

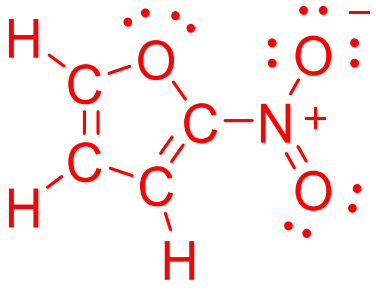


Q

(A) compound **Q** has the IUPAC name 1-methylcyclohexane
(B) compound **Q** is an isomer of 1,1,2,2-tetramethylcyclopropane
(C) compound **Q** has two chair conformations of equal potential energy
(D) compound **Q** has a tertiary (3°) carbon but not a tertiary hydrogen atom

Problem II. Lewis Structure (10 points). Complete the Lewis structure for 2-nitrofuran (**R**) that has been started on your answer sheet. The compound has the molecular formula $C_4H_3NO_3$. All atoms in the structure (aside from hydrogen) have full octets. All of the carbon atoms in the ring are sp^2-hybridized. Explicitly include—i.e., draw out—all hydrogens, bonding pairs, lone pairs, and non-zero formal charges on your Lewis structure. If you are considering multiple resonance forms, choose the one that seems most favorable.

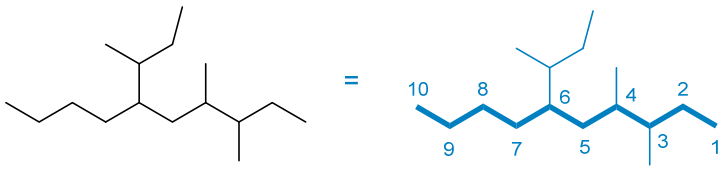




R

Problem III. Alkanes and Substituted Alkanes (14 points). Provide the systematic IUPAC names requested below.

(1) (7 points) Provide the systematic name for compound **S**. Ignore stereochemistry, since none is indicated anyway.



S

6-*sec*-butyl-3,4-dimethyldecane

The longest chain has ten carbons (shown in bold) and the tiebreaker for deciding from what end to begin numbering it is that the locant for the first substituent will be 3 vs. 5.

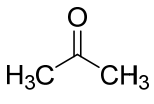
(2) (7 points) Provide the systematic name for the smallest (by mass) acyclic alkane (no rings) that has a methyl group with a locant of 3 (at C3 in the chain) and ethyl group with a locant of 4.

These compounds are all $C_{10}H_{22}$ and acceptable answers:

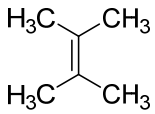
4-ethyl-3-methylheptane
4-ethyl-2,3-dimethylhexane
4-ethyl-3,3-dimethylhexane

Problem IV. Explanations (16 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) (8 points) Of compounds **T** and **U**, which is the stronger acid?



T



U

Compound **T**. The compound with the lower pK_a will be the stronger acid. The best way to gauge this acidity is by looking at the relative stability of the conjugate bases that result from removal of a proton from either compound. Resonance in both, electron pair is delocalized to a more electronegative atom for **T**.

(2) (8 points) Of cyclohexane (**X**) and cyclobutane (**Y**), which has more ring strain?

X

Y

Compound **Y**. All carbon atoms are sp^3-hybridized and prefer bond angles of 109.5°. Cyclohexane's chair conformations have this angle. Cyclobutane cannot adopt that structure and has bond angles much smaller, which is relatively unfavorable.