

CHEM 3311-100
Exam 1 KEY
February 12, 2013

Time: 2 Hours

By printing my name and signing on this cover page, I pledge that
“On my honor, as a University of Colorado-Boulder student, I have neither given nor received unauthorized assistance on this work.”

PRINT (**Capital Letters**) LAST, FIRST NAME

Please sign here

General Instructions

- 1) Please turn off your cell phone (contact me if you **MUST** have your cell phone on) and place it in your backpack.
- 2) This is a **CLOSED BOOK** exam; nothing is allowed except your student ID, a few pencils or pens, eraser, and **molecular models in a transparent/clear Ziploc bag** (quart size).
- 3) In the space below the double lines (for handwritten work), please copy the honor code (shown above) and sign your name.
- 4) Use the blank areas of the exam for scratch work; scratch paper will be provided as needed.
- 5) Your scantron **MUST INCLUDE** your (i) name, (ii) student ID #, and (iii) recitation section #. Please follow the detailed instructions provided below.
- 6) If suspected of/caught cheating, you will receive at best an F for the exam. The instructor reserves the right to proceed further in compliance with university policies on academic violations.
- 7) You may **NOT** leave the room after the exam has started to minimize disruptions to other students (contact a proctor if there are extenuating circumstances). When you finish the exam, **please return the completed scantron sheet AND this signed cover page** to the exam proctors, and leave as quietly as possible. You are allowed to take the exam pages 1-5 and scratch paper with you.

On the computer graded answer sheet (also known as a scantron), enter **your name** and **student identification number** in the appropriate boxes. Enter the number of your recitation section in the four columns at the upper left of the sheet. (Use a zero before the recitation section number - for example, section 237 is written as 0237.) Then **fill in the corresponding bubbles below your name, ID number, and recitation section.**

Answer all questions on the computer graded answer sheets by filling in the proper bubble with a No. 2 pencil. If you change an answer, erase the undesired mark thoroughly. Mark only the best answer to each question. Programmable calculators are not permitted during the exam.

A section of the Periodic Table with atomic numbers and masses is shown on this cover page. A Table of pK_a values is included here. Use the back of the exam pages as scratch paper. There are **5 exam pages** (with 25 questions), a cover page, and two blank pages (scratch paper). When you are instructed to begin the exam, please check that you have all pages. Good luck!

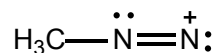
1 H	
3 Li	4 Be
11 Na	12 Mg

				2 He	
5 B	6 C	7 N	8 O	9 F	10 Ne
13 Al	14 Si	15 P	16 S	17 Cl	18 Ar

Table of Acidities

<u>Acid</u>	<u>pK_a Value</u>
HI	-10.1
HCl	-3.9
H ₃ O ⁺	-1.7
CH ₃ COOH	4.7
NH ₄ ⁺	9.3
Phenol	10
H ₂ O	15.7
Alcohols	16-18
HC=CH	26
NH ₃	36
H ₂	37
H ₂ C=CH ₂	45
CH ₄	60

1. Draw the *best* Lewis structure for nitric acid, HNO_3 . What is the formal charge on N in this structure?
 (A) +2 **(B) +1** (C) 0 (D) -1
2. Draw the *best* Lewis structure for acetonitrile, CH_3CN . Select *all the statements* that correctly describe this Lewis structure. [Hint: Carbon atoms are connected.]
 (I) There are 2 lone pairs on the N atom.
 (II) There is a triple bond between the central C and N.
 (III) The CCN bond angle is 180° .
 (A) I and II (B) I and III **(C) II and III** (D) I, II, and III
3. What is the shape of the formaldehyde (CH_2O) molecule?
 (A) Bent (B) Linear (C) Tetrahedral **(D) Trigonal planar**
4. Use curved arrows to draw a *more stable* contributing Structure II for the species shown below.



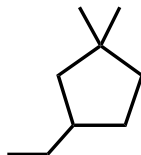
Structure I

Which of these represents Structure II?

- (A) $\text{H}_3\text{C}-\overset{+}{\text{N}}\equiv\text{N}:$ (B) $\text{H}_3\text{C}-\overset{+}{\text{N}}\equiv\text{N}$ (C) $\text{H}_3\text{C}-\overset{\cdot\cdot}{\underset{+}{\text{N}}}-\overset{\cdot\cdot}{\text{N}}:$ (D) $\text{H}_2\text{C}=\overset{+}{\text{N}}=\overset{-}{\text{N}}:$

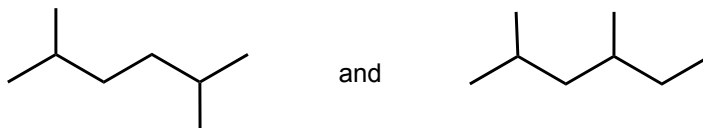
Correct Answer: A

5. The compound $\text{CH}_3\text{CH}=\text{C}=\text{CHCH}_3$ (2,3-pentadiene) is a cumulated diene. What type of orbital overlap is responsible for the C3-C2 and C3-C4 *sigma* bonds?
 (A) *p-p* (B) *sp-sp* **(C) *sp-sp*²** (D) *sp-sp*³
6. Which of these is 2,2,5-trimethylhexane?
 (A) $(\text{CH}_3)_2\text{CHCH}_2\text{C}(\text{CH}_3)_3$
 (B) $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{C}(\text{CH}_3)_3$
(C) $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{C}(\text{CH}_3)_3$
 (D) $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{CH}_2\text{C}(\text{CH}_3)_3$
7. What is the IUPAC name of the compound shown?

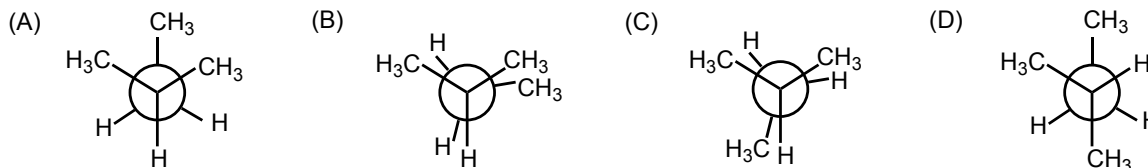


- (A) 1-Ethyl-3,3-dimethylcyclopentane
 (B) 1-Ethyl-4,4-dimethylcyclopentane
(C) 3-Ethyl-1,1-dimethylcyclopentane
 (D) 4-Ethyl-1,1-dimethylcyclopentane

8. What is the relationship between the molecules whose structures are shown below?

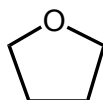


- (A) **Constitutional isomers** (B) Compounds with different molecular formulas
 (C) Identical (D) Resonance forms
9. The heats of combustion of heptane and 3,3-dimethylpentane are -4817 and -4809 kJ/mol, respectively. Select the correct statement.
- (A) Heptane is 8 kJ/mol more stable than 3,3-dimethylpentane.
 (B) **3,3-Dimethylpentane is 8 kJ/mol more stable than heptane.**
 (C) Stabilities cannot be compared since these molecules are not isomers.
 (D) Stabilities cannot be compared since these molecules form different combustion products.
10. Which is the *most stable* conformation of 2-methylbutane?



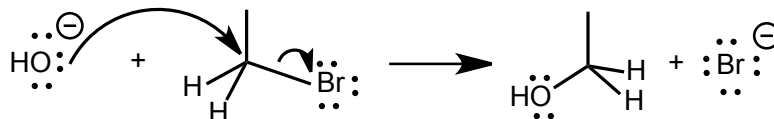
Correct Answer: D

11. Which organic solvent is nonpolar?
- (A) **CS₂** (B) CH₂Cl₂ (C) CH₃OH (D) CH₃COOH
12. Which sequence represents *increasing* boiling points?
- (A) C₂H₅OH < CH₃CH₂CH₃ < CH₃OCH₃
 (B) CH₃OCH₃ < CH₃CH₂CH₃ < C₂H₅OH
 (C) **CH₃CH₂CH₃ < CH₃OCH₃ < C₂H₅OH**
 (D) C₂H₅OH < CH₃OCH₃ < CH₃CH₂CH₃
13. Tetrahydrofuran (THF) is used as a solvent in reactions of alkenes with BH₃ (hydroboration of alkenes). What is the role of THF in this acid-base reaction? The structure of THF is shown below.

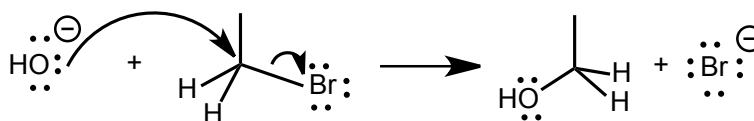


- (A) Bronsted acid (B) Bronsted base (C) Lewis acid (D) **Lewis base**

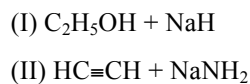
14. Frontier orbitals participate in an organic chemical reaction. Examine the nucleophilic substitution reaction shown below and identify the HOMO and LUMO in this example.



- (A) HOMO is sp^2 orbital of O in the hydroxide ion; LUMO is σ^*_{C-Br} .
 (B) HOMO is sp^2 orbital of O in the hydroxide ion; LUMO is σ_{C-Br} .
(C) HOMO is sp^3 orbital of O in the hydroxide ion; LUMO is σ^*_{C-Br} .
 (D) HOMO is sp^3 orbital of O in the hydroxide ion; LUMO is σ_{C-Br} .
15. Which is the nucleophile in the reaction shown?

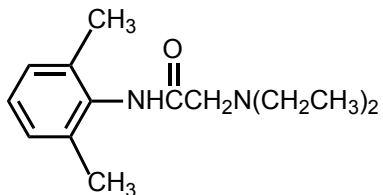


- (A) Hydroxide ion** (B) CH_3CH_2Br (C) CH_3CH_2OH (D) Bromide ion
16. The pK_a of F_3C-CH_2OH is about 11-12.5 while the pK_a of CH_3CH_2SH is 10.6. Select the statement that is a correct interpretation of these experimental data.
- (A) F_3C-CH_2OH and CH_3CH_2SH have exactly the same acid strength.
 (B) F_3C-CH_2OH is a stronger acid than CH_3CH_2SH .
 (C) The inductive effect makes F_3C-CH_2OH the relatively stronger acid.
(D) The weaker S-H bond strength influences acidity more than the inductive effect in F_3C-CH_2OH .
17. Select the relatively **strongest** base.
- (A) $CH_3CH_2CH_2CH_2Li$ (n-butyl lithium)** (B) $(CH_3)_2CHNHLi$ (lithium diisopropylamide)
 (C) C_2H_5ONa (sodium ethoxide) (D) CH_3COONa (sodium acetate)
18. Which of these acid-base reactions are synthetically useful for **quantitative preparation** of the product(s)?



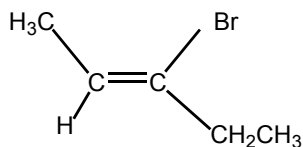
- (A) I only (B) II only **(C) Both I and II** (D) Neither I nor II

19. Recognize and identify the functional groups in the anesthetic *lidocaine*.

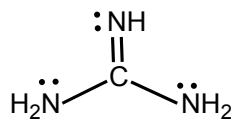


- (A) Secondary amine and ketone
 (C) Primary amine and aldehyde
- (B) **Amide and tertiary amine**
 (D) Ester and secondary amine
20. Which sequence represents *increasing* alkane stability?
- (A) **$\text{CH}_3(\text{CH}_2)_3\text{CH}_3 < (\text{CH}_3)_2\text{CHCH}_2\text{CH}_3 < (\text{CH}_3)_2\text{C}(\text{CH}_3)_2$**
 (B) $(\text{CH}_3)_2\text{C}(\text{CH}_3)_2 < (\text{CH}_3)_2\text{CHCH}_2\text{CH}_3 < \text{CH}_3(\text{CH}_2)_3\text{CH}_3$
 (C) $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3 < \text{CH}_3(\text{CH}_2)_3\text{CH}_3 < (\text{CH}_3)_2\text{C}(\text{CH}_3)_2$
 (D) $(\text{CH}_3)_2\text{C}(\text{CH}_3)_2 < \text{CH}_3(\text{CH}_2)_3\text{CH}_3 < (\text{CH}_3)_2\text{CHCH}_2\text{CH}_3$
21. Alkanes, when reacted with Br_2 in the presence of light, form alkyl halides (H atoms in an alkane are substituted by Br atoms). Assuming that only *monobrominated* products are formed, how many different alkyl monobromides will be obtained from 2,2,3-trimethylbutane?
- (A) 1 (B) 2 (C) **3** (D) 4
22. Which compound is a terminal alkene?
- (A) **1-Pentene**
 (B) (*E*)-2-Pentene
 (C) (*Z*)-2-Pentene
 (D) 2-Methyl-2-Butene
23. Which compound *cannot* exist as *E* and *Z* isomers?
- (A) $\text{ClCH}=\text{CHCl}$
 (B) $\text{BrClC}=\text{CHCH}_3$
 (C) **$(\text{CH}_3)_2\text{C}=\text{CHCl}$**
 (D) $\text{ClCH}=\text{CBrF}$

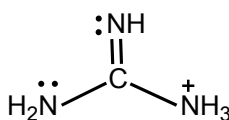
24. What is the IUPAC name of the compound shown?



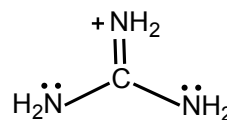
- (A) (*E*)-3-Bromo-2-pentene
(B) (*Z*)-3-Bromo-2-pentene
 (C) (*E*)-3-Bromo-3-pentene
 (D) (*Z*)-3-Bromo-3-pentene
25. Structures I and II are possible for the conjugate acid (guanidinium ion) of guanidine. Considering the importance of resonance, select the statement that correctly describes Structure I and Structure II.



Guanidine



Structure I



Structure II

- (A) I and II are related as contributing resonance structures for the guanidinium ion.
 (B) Structure I is more stable as it is better stabilized by resonance.
(C) Structure II is more stable as it is better stabilized by resonance.
 (D) Neither Structure I nor Structure II is stabilized by resonance.