

**CHEM 3311-100**  
**Exam 1**  
**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 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 110 is written as 0110.) 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!

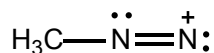
1 H	
3 Li	4 Be
11 Na	12 Mg

				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><math>pK_a</math> Value</u>
HI	-10.1
HCl	-3.9
$H_3O^+$	-1.7
$CH_3COOH$	4.7
$NH_4^+$	9.3
Phenol	10
$H_2O$	15.7
Alcohols	16-18
$HC=CH$	26
$NH_3$	36
$H_2$	37
$H_2C=CH_2$	45
$CH_4$	60

- Draw the *best* Lewis structure for nitric acid,  $\text{HNO}_3$ . What is the formal charge on N in this structure?  
 (A) +2                      (B) +1                      (C) 0                      (D) -1
- Draw the *best* Lewis structure for acetonitrile,  $\text{CH}_3\text{CN}$ . 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  $180^\circ$ .  
 (A) I and II                      (B) I and III                      (C) II and III                      (D) I, II, and III
- What is the shape of the formaldehyde ( $\text{CH}_2\text{O}$ ) molecule?  
 (A) Bent                      (B) Linear                      (C) Tetrahedral                      (D) Trigonal planar
- Use curved arrows to draw a *more stable* contributing Structure II for the species shown below.

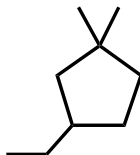


Structure I

Which of these represents Structure II?

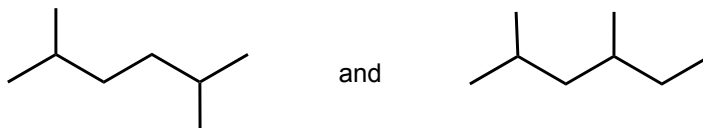
- (A)  $\text{H}_3\text{C}-\overset{+}{\text{N}}\equiv\text{N}:$       (B)  $\text{H}_3\text{C}-\overset{+}{\text{N}}\equiv\text{N}$       (C)  $\text{H}_3\text{C}-\overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{N}}}-\overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{N}}}: \quad \text{(D)} \quad \text{H}_2\text{C}=\overset{+}{\text{N}}=\overset{-}{\text{N}}:$

- 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*<sup>2</sup>                      (D) *sp-sp*<sup>3</sup>
- 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)  $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{CH}_2\text{C}(\text{CH}_3)_3$
- What is the IUPAC name of the compound shown?

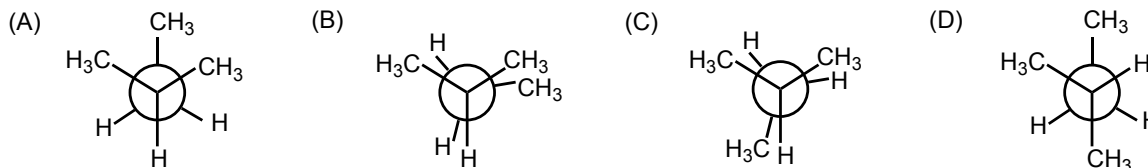


- (A) 1-Ethyl-3,3-dimethylcyclopentane  
 (B) 1-Ethyl-4,4-dimethylcyclopentane  
 (C) 3-Ethyl-1,1-dimethylcyclopentane  
 (D) 4-Ethyl-1,1-dimethylcyclopentane

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



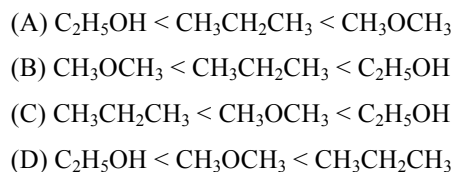
- (A) Constitutional isomers  
(B) Compounds with different molecular formulas  
(C) Identical  
(D) Resonance forms
9. The heats of combustion of heptane and 3,3-dimethylpentane are -4817 and -4809 kJ/mol, respectively. Select the correct statement.
- (A) Heptane is 8 kJ/mol more stable than 3,3-dimethylpentane.  
(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?



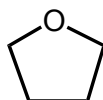
11. Which organic solvent is nonpolar?



12. Which sequence represents *increasing* boiling points?

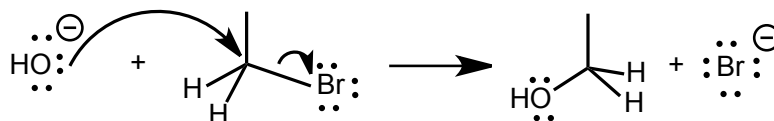


13. Tetrahydrofuran (THF) is used as a solvent in reactions of alkenes with BH<sub>3</sub> (hydroboration of alkenes). What is the role of THF in this acid-base reaction? The structure of THF is shown below.

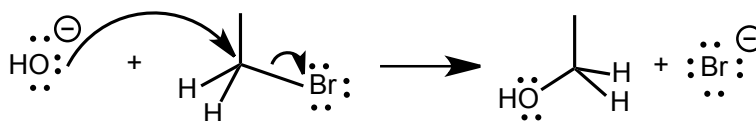


- (A) Bronsted acid                      (B) Bronsted base                      (C) Lewis acid                      (D) Lewis base

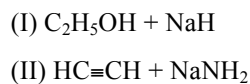
14. Frontier orbitals participate in an organic chemical reaction. Examine the nucleophilic substitution reaction shown below and identify the HOMO and LUMO in this example.



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

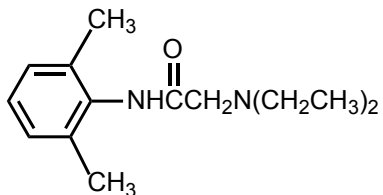


- (A) Hydroxide ion      (B)  $CH_3CH_2Br$       (C)  $CH_3CH_2OH$       (D) Bromide ion
16. The  $pK_a$  of  $F_3C-CH_2OH$  is about 11-12.5 while the  $pK_a$  of  $CH_3CH_2SH$  is 10.6. Select the statement that is a correct interpretation of these experimental data.
- (A)  $F_3C-CH_2OH$  and  $CH_3CH_2SH$  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)?



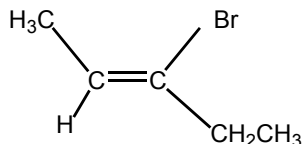
- (A) I only      (B) II only      (C) Both I and II      (D) Neither I nor II

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

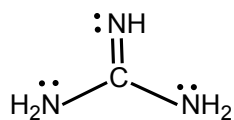


- (A) Secondary amine and ketone  
(B) Amide and tertiary amine  
(C) Primary amine and aldehyde  
(D) Ester and secondary amine
20. Which sequence represents *increasing* alkane stability?
- (A)  $\text{CH}_3(\text{CH}_2)_3\text{CH}_3 < (\text{CH}_3)_2\text{CHCH}_2\text{CH}_3 < (\text{CH}_3)_2\text{C}(\text{CH}_3)_2$   
(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  $\text{Br}_2$  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)  $\text{ClCH}=\text{CBrF}$

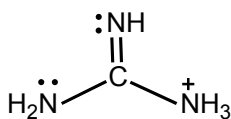
24. What is the IUPAC name of the compound shown?



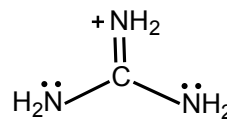
- (A) (*E*)-3-Bromo-2-pentene  
 (B) (*Z*)-3-Bromo-2-pentene  
 (C) (*E*)-3-Bromo-3-pentene  
 (D) (*Z*)-3-Bromo-3-pentene
25. Structures I and II are possible for the conjugate acid (guanidinium ion) of guanidine. Considering the importance of resonance, select the statement that correctly describes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