

**CHEM 3311-200**  
**Exam 1**  
**September 25, 2012**

**Time: 2 Hours**

By printing my name below, I pledge that  
"On my honor, as a University of Colorado-Boulder student, I have neither given nor received unauthorized assistance on this work."

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 to the exam proctors** at the front desk, and leave as quietly as possible. You are allowed to take the exam 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><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
$HC\equiv CH$	26
$NH_3$	36
$H_2C=CH_2$	45
$CH_4$	60

1. Which of the following molecules would you expect to have a dipole moment?

I. HCN

II. CS<sub>2</sub>

III. CH<sub>2</sub>Br<sub>2</sub>

(A) I and II

(B) I and III

(C) II and III

(D) I, II and III

2. Draw Lewis structures for methanol and 1-hexanol. Select the statement that **correctly** describes either or both of these molecules.

(A) Methanol is relatively more soluble in water than 1-hexanol.

(B) Methanol has a higher boiling point than 1-hexanol.

(C) Both are nonpolar solvents.

(D) Methanol is nonpolar and 1-hexanol is polar.

3. Compare the shapes of the nitrite ion, NO<sub>2</sub><sup>-</sup>, and the nitronium ion, NO<sub>2</sub><sup>+</sup>.

(A) Both ions are linear.

(B) Both ions are bent (angular).

(C) The nitrite ion is linear and the nitronium ion is bent.

(D) The nitrite ion is bent and the nitronium ion is linear.

4. What is the hybridization of the central N atom in the nucleophilic azide ion, N<sub>3</sub><sup>-</sup>?

(A) sp<sup>3</sup>

(B) sp<sup>2</sup>

(C) sp

(D) none of these

5. Draw all the constitutional isomers of C<sub>6</sub>H<sub>14</sub>. How many of these isomers contain **only primary and tertiary** carbon atoms.

(A) 0

(B) 1

(C) 2

(D) 3

6. The name 2,3-dimethyl-3-propylpentane is an incorrect IUPAC name. What is its correct IUPAC name?

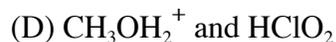
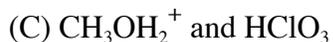
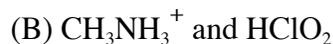
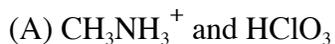
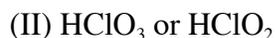
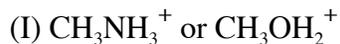
(A) 3-isopropyl-3-methylhexane

(B) 3-ethyl-2,3-dimethylhexane

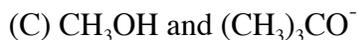
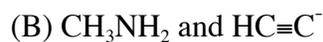
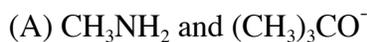
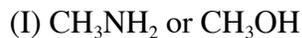
(C) 4-isopropyl-4-methylhexane

(D) 4-ethyl-4,5-dimethylhexane

7. Select the stronger acid in each pair.



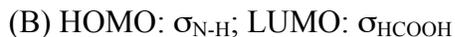
8. Select the stronger base in each pair.



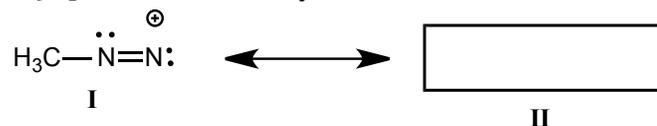
9. The compound methyl butanoate,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_3$ , has a  $\text{pK}_a$  value of 22. Predict the magnitude of the equilibrium constant when this compound reacts with the methoxide ion,  $\text{CH}_3\text{O}^-$ . (The acidic H is attached to the **alpha carbon** that is in bold font and underlined.)



10. Apply Frontier Orbital Theory to identify the HOMO and LUMO in the reaction between  $\text{CH}_3\text{NH}_2$  and  $\text{HCOOH}$ .



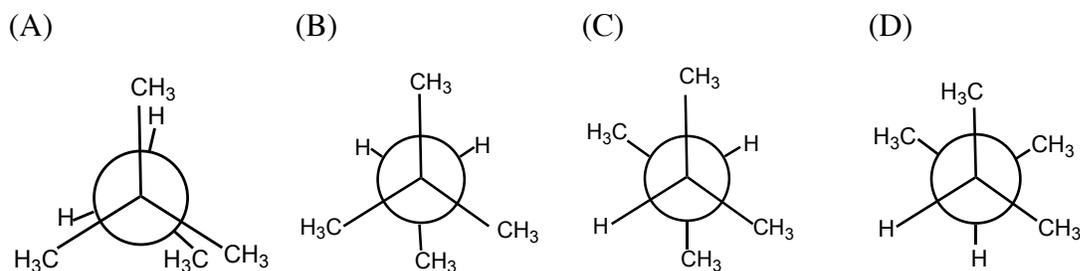
11. The structure of  $\text{CH}_3\text{N}_2^+$  is a resonance hybrid of 2 structures. One of these is shown below:



Using the curved arrow notation, draw the second (**II**) contributing Lewis structure. Then, select the statement that best describes the resonance hybrid for the structure of  $\text{CH}_3\text{N}_2^+$ .

- (A) Both structures contribute equally to the structure of the cation.  
 (B) Structure **I** is the major contributor to the structure of the cation.  
 (C) Structure **II** is the major contributor to the structure of the cation.  
 (D) Structures **I** and **II** are in equilibrium.

12. Select the most stable conformation of 2,3-dimethylbutane, sighting down the C2-C3 bond.



13. Classify the reaction of the azide ion,  $\text{N}_3^-$ , with ethyl iodide to form azidoethane.

- (A) Addition reaction  
 (B) Bronsted acid-base reaction  
 (C) Lewis acid-base reaction  
 (D) Nucleophilic substitution reaction

14. Which compound has the highest boiling point?

- (A) Butane  
 (B) Ethyl methyl ether  
 (C) Propyl alcohol  
 (D) All these compounds have approximately the same molar mass; hence, the boiling points are the same.

15. Which of the following alkenes exhibit E-Z isomerism?



- (A) **I** and **II**      (B) **I** and **III**      (C) **II** and **III**      (D) **I**, **II** and **III**

16. Select the thermodynamically most stable alkene.

- (A) 1-hexene      (B) (E)-3-hexene      (C) (Z)-3-hexene      (D) 2-methyl-2-pentene

17. Which alkene releases the *least* energy on combustion in kJ/mol?

- (A) 2,4,4-trimethyl-2-pentene  
(B) 1-heptene  
(C) (Z)-3,4-dimethyl-2-pentene  
(D) 2,4-dimethyl-1-pentene

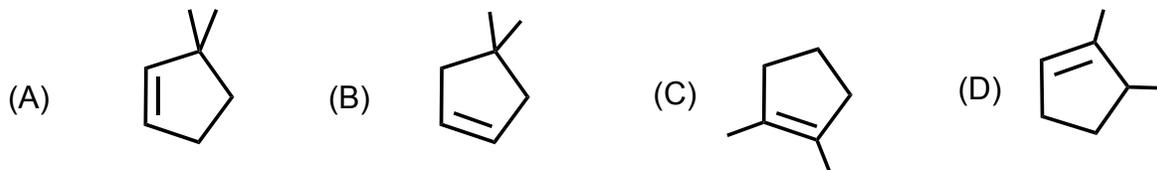
18. Select the alkene with the lowest  $E_a$  (activation energy) in the reaction with HCl.

- (A) 1-hexene      (B) (E)-3-hexene      (C) (Z)-3-hexene      (D) 2-methyl-2-pentene

19. Select the Markovnikov product in the reaction of 2-methylpropene with HI.

- (A) 2-iodo-2-methylpropane  
(B) 2-iodo-2-methylpropene  
(C) 1,2-diiodopropane  
(D) 1,2-diiodopropene

20. An alkene X with molecular formula  $C_7H_{12}$  reacts with HBr to give a *single* alkyl halide with molecular formula  $C_7H_{13}Br$ . On catalytic hydrogenation, X is converted to 1,1-dimethylcyclopentane. What is the chemical identity of X?



21. Which reagents should be employed to convert 1-butene to butane?

- (A) HI  
(B) 1 M  $HNO_3$   
(C)  $H_2$ , Pd/C  
(D) None of these

22. When HI is added to an alkene, the first mechanistic step of the reaction involves the \_\_\_\_\_ to the alkene.

- (A) Fast addition of an electrophile
- (B) Slow addition of an electrophile
- (C) Fast addition of a nucleophile
- (D) Slow addition of a nucleophile

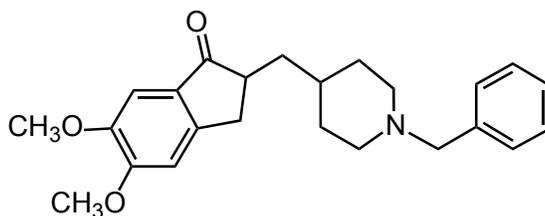
23. The rearrangement that occurs when 3-methyl-1-butene reacts with HBr can be described as a (Note: C1, C2, C3, etc. refers to numbering of carbon atoms in the starting alkene.):

- (A) hydride shift from C2 to C1
- (B) hydride shift from C3 to C2
- (C) methyl shift from C3 to C1
- (D) methyl shift from C3 to C2

24. Predict the major product when 3,3-dimethyl-1-butene is reacted with catalytic amounts of aqueous  $\text{H}_2\text{SO}_4$ .

- (A) 3,3-dimethyl-2-butanol
- (B) 2,2-dimethyl-3-butanol
- (C) 2,3-dimethyl-2-butanol
- (D) 2,3-dimethyl-3-butanol

25. Donepezil (trade name is Aricept) is used in the treatment of mild to moderate dementia associated with Alzheimer's disease. The structure is shown below. What are some of the functional groups in this molecule?



- (A) aldehyde, amine, ester
- (B) amide, ester, ketone
- (C) aldehyde, amide, ether
- (D) amine, ether, ketone