

## CHEM 3311-100

## Exam 2

March 12, 2013

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."

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 PRINT YOUR FIRST & LAST NAME

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 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 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

**Table of Acidities**

<u>Acid</u>	<u><math>pK_a</math> Value</u>
Alcohols	16-18
$HC\equiv CH$	26
$NH_3$	36
$H_2$	37
$H_2C=CH_2$	45
$CH_4$	60

1. Circle the *incorrect* statement.

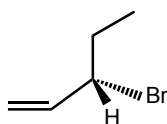
- (A) Achiral molecules are optically inactive.  
 (B) Enantiomers rotate plane-polarized light through the same angle in opposite directions.  
 (C) Meso compounds do not contain asymmetric carbon atoms and are achiral.  
 (D) Racemic mixtures contain equimolar amounts of enantiomers.

2. Indicate whether each statement is true or false. Then, select the best answer.

- (I) All asymmetric carbon atoms are stereocenters, but not all carbon stereocenters are asymmetric.  
 (II) The compound  $\text{CH}_3\text{CHOHCHOHCHOHCH}_3$  has two meso stereoisomers.

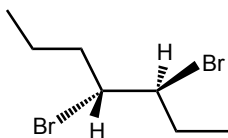
- (A) Statement I is false and statement II is true.  
 (B) Statement I is true and statement II is false.  
 (C) Both statements are false.  
 (D) Both statements are true.

3. Select the *correct* IUPAC name for the compound shown.



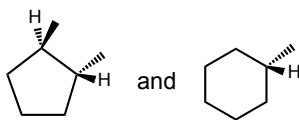
- (A) (R)-3-Bromo-1-pentene  
 (B) (S)-3-Bromo-1-pentene  
 (C) (R)-3-Bromo-4-pentene  
 (D) (S)-3-Bromo-4-pentene

4. Select the *correct* IUPAC name for the dibromoalkane shown.



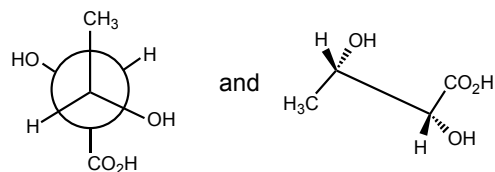
- (A) (3S,4R)-3,4-Dibromoheptane  
 (B) (3R,4S)-3,4-Dibromoheptane  
 (C) (4S,5R)-3,4-Dibromoheptane  
 (D) (4R,5S)-3,4-Dibromoheptane

5. What is the relationship between the molecules shown?



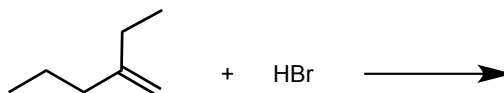
- (A) Constitutional Isomers  
 (B) Diastereomers  
 (C) Enantiomers  
 (D) Identical

6. What is the relationship between the molecules shown?



- (A) Constitutional Isomers      (B) Diastereomers      (C) Enantiomers      (D) Identical

7. Consider the reaction of 2-ethyl-1-pentene with HBr.



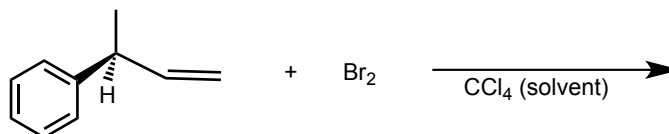
What is the stereochemical relationship of the major products formed in this reaction?

- (A) Constitutional Isomers      (B) Diastereomers      (C) Enantiomers      (D) Identical

8. Compound X on reaction with Br<sub>2</sub> in CH<sub>2</sub>Cl<sub>2</sub> (solvent) produced *meso*-2,3-dibromobutane as the only product. What is the chemical identity of compound X?

- (A) 1-Butene      (B) (*E*)-2-Butene      (C) (*Z*)-2-Butene      (D) 2-Methylpropene

9. Consider the reaction depicted below:



What is the stereochemical outcome of this reaction?

- (A) Diastereomers, equal amounts      (B) Diastereomers, unequal amounts  
(C) Enantiomers, equal amounts      (D) Enantiomers, unequal amounts

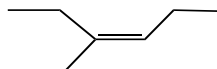
10. Which compound releases the smallest amount of heat on combustion?

- (A) Cyclopentane      (B) Methylcyclobutane  
(C) *cis*-1,2-Dimethylcyclopropane      (D) *trans*-1,2-Dimethylcyclopropane

11. Which constitutional isomer of dimethylcyclohexane does not exhibit *cis-trans* isomerism?

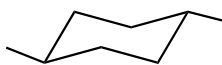
- (A) 1,1-Dimethylcyclohexane      (B) 1,2-Dimethylcyclohexane  
(C) 1,3-Dimethylcyclohexane      (D) 1,4-Dimethylcyclohexane

12. The major product in the addition of  $\text{Br}_2$  in  $\text{CH}_3\text{OH}$  (solvent) to (Z)-3-methyl-3-hexene is:



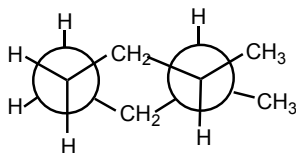
- (A) a racemic mixture of (3R,4S)-3-bromo-4-methoxy-3-methylhexane and (3S,4R)-4-bromo-3-methoxy-3-methylhexane.  
 (B) a racemic mixture of (3R,4R)-3-bromo-4-methoxy-3-methylhexane and (3S,4S)-4-bromo-3-methoxy-3-methylhexane.  
 (C) a racemic mixture of (3R,4S)-4-bromo-3-methoxy-3-methylhexane and (3S,4R)-4-bromo-3-methoxy-3-methylhexane.  
 (D) a racemic mixture of (3R,4R)-4-bromo-3-methoxy-3-methylhexane and (3S,4S)-4-bromo-3-methoxy-3-methylhexane.

13. Select the IUPAC name of the compound shown below.



- (A) *cis*-1,3-Dimethylcyclohexane  
 (B) *trans*-1,3-Dimethylcyclohexane  
 (C) *cis*-1,4-Dimethylcyclohexane  
 (D) *trans*-1,4-Dimethylcyclohexane

14. The structure shown below is the Newman projection for the:



- (A) least stable chair conformation of *cis*-1,2-dimethylcyclohexane  
 (B) most stable chair conformation of *cis*-1,2-dimethylcyclohexane  
 (C) least stable chair conformation of *trans*-1,2-dimethylcyclohexane  
 (D) most stable chair conformation of *trans*-1,2-dimethylcyclohexane

15. Which isomer is the **least stable**? [Hint: Consider 1,3-diaxial interactions and gauche interactions.]

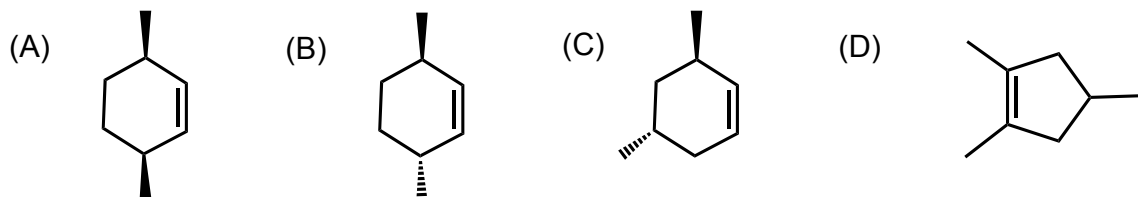
- (A) *cis*-1,2-dimethylcyclohexane  
 (B) *trans*-1,2-dimethylcyclohexane  
 (C) *cis*-1,3-dimethylcyclohexane  
 (D) *trans*-1,3-dimethylcyclohexane

16. For which of these reactions is a concerted, single-step mechanism proposed?

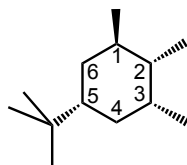
- (I) (Z)-2-Butene +  $\text{Br}_2$  in  $\text{H}_2\text{O}$  as solvent  
 (II) (Z)-2-Butene + HBr

- (A) I  
 (B) II  
 (C) I and II  
 (D) none of these

17. An *optically active* compound **Y** (molecular formula is  $C_8H_{14}$ ) on catalytic hydrogenation produces an *optically inactive* product. Which structure for **Y** is consistent with the data provided?



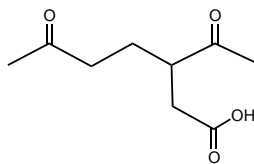
18. Draw the *most stable* chair conformation for the molecule shown below.



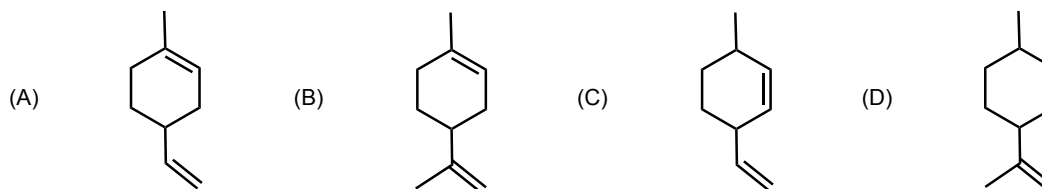
Which statement *correctly* describes the axial and equatorial orientations of the alkyl groups in the *most stable* chair conformation?

- (A) The methyl group attached to carbon 1 is equatorial.  
 (B) The methyl group attached to carbon 2 is equatorial.  
 (C) The methyl group attached to carbon 3 is equatorial.  
 (D) The *tert*-butyl group attached to carbon 5 is axial.

19. Ozonolysis of compound **Z** (molecular formula is  $C_{10}H_{16}$ ) followed by treatment of the reaction mixture with  $H_2O_2$  produced the major product shown below:



What is the structure of compound **Z**?



20. When 3-methyl-1-butene is reacted with  $HCl$  at  $0^\circ C$ , a mixture of products is obtained. The major product is formed in 60% yield. What is the *structure of this major product*?

- (A) 1-Chloro-3-methylbutane  
 (B) 2-Chloro-3-methylbutane  
 (C) 1-Chloro-2-methylbutane  
 (D) 2-Chloro-2-methylbutane

21. Which reaction proceeds by anti addition?

- (A) 1,2-Dimethylcyclohexene + Br<sub>2</sub>/H<sub>2</sub>O      (B) 1,2-Dimethylcyclohexene + peroxyacetic acid  
 (C) 1,2-Dimethylcyclohexene + H<sub>2</sub>/Pt  
 (D) 1,2-Dimethylcyclohexene + BH<sub>3</sub>/THF, followed by H<sub>2</sub>O<sub>2</sub>/NaOH

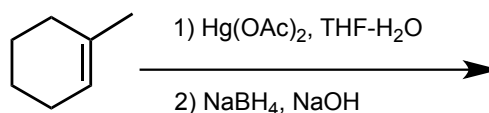
22. Which statement *correctly* describes free radicals and reactions involving free radical mechanisms?

- (A) Free radicals are species with paired electrons.  
 (B) The peroxy linkage in di-*tert*-butyl peroxide is a strong bond.  
 (C) Secondary free radicals are always more stable than tertiary free radicals.  
 (D) Termination reactions are always exothermic.

23. Write out the mechanism for the reaction of propene with HBr in the presence of di-*tert*-butyl peroxide. Now, consider the propagation steps for this reaction. Classify the intermediate carbon-centered radical in the *first propagation step*.

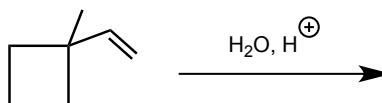
- (A) Methyl radical      (B) Primary radical  
 (C) Secondary radical      (D) Tertiary radical

24. Describe the product or products formed in the reaction shown below:

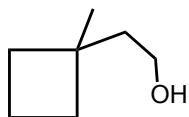
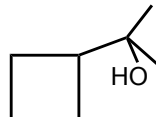
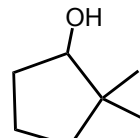


- (A) A single achiral product      (B) Constitutional isomers  
 (C) Diastereomers      (D) Enantiomers

25. Write out the mechanism for this reaction, paying attention to the possibility of rearrangements.



Which of these is the major product in this reaction, assuming rearrangements are very fast?

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