

Please read and sign the Honor Code statement below:

I pledge that on my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this exam.

\_\_\_\_\_  
Signature

**General Instructions:** There are 25 questions. Be sure you have them all. Read each question carefully so that you know exactly what is being asked.

Each multiple choice question (1-25) is worth **4 points and has only one correct answer**. Bubble in your answers to these questions on the Scantron provided. Only the Scantron will be graded.

**Your Scantron should include your name, student ID number, and recitation section number.**

At the end of the exam, turn in your Scantron and this signed cover sheet. You may keep the rest of the exam to check your answers against the key later.

Good luck!

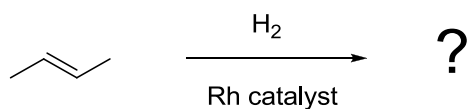
**PERIODIC CHART OF THE ELEMENTS**

IA	IIA	IIIB	IVB	VB	VIB	VIIIB	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES		
1 H 1.00797														1 H 1.00797	2 He 4.0026		
3 Li 6.939	4 Be 9.0122										5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183	
11 Na 22.9898	12 Mg 24.312										13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948	
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	+89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 ? (271)	111 ? (272)	112 ? (277)						

1. Which of these molecules has the *highest*  $pK_a$ ?

- a.  $CH_4$
- b.  $NH_3$
- c.  $H_2O$
- d.  $HF$
- e. They all have the same  $pK_a$

2. Is this reaction an oxidation, a reduction, or neither?



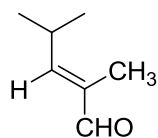
- a. oxidation
  - b. reduction
  - c. neither
3. Which of the following alkene isomers is the most stable?

- a. 2-methyl-2-butene
- b. *cis*-2-pentene
- c. 1-pentene
- d. *trans*-2-pentene
- e. There is not enough information to answer the question.

4. Which of these reactions is properly classified as a *syn* addition?

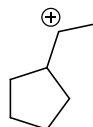
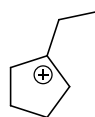
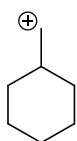
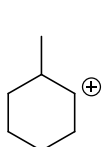
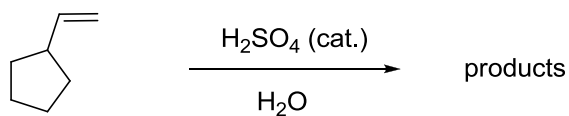
- a. Oxymercuration-demercuration
- b. Ozonolysis
- c. Hydroboration-oxidation
- d. Addition of bromine to an alkene
- e. Addition of bromine and water to an alkene

5. Is this alkene properly classified as *E* or *Z*?



- a. *E*
- b. *Z*

6. Which of these structures is *not* a possible intermediate under the reaction conditions shown?



All of these are possible intermediates

**A**

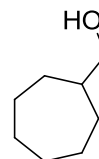
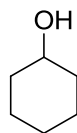
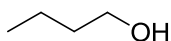
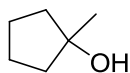
**B**

**C**

**D**

**E**

7. Which of these alcohols is a secondary alcohol?



None of these are secondary alcohols

**A**

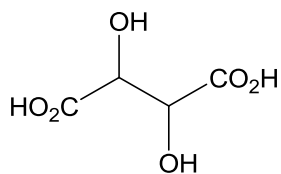
**B**

**C**

**D**

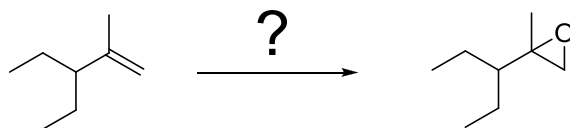
**E**

8. How many stereoisomers exist for this structure?

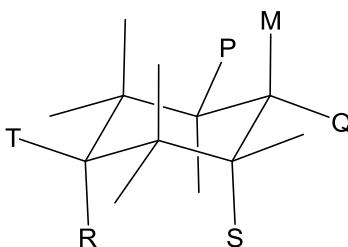


- a. 1  
 b. 2  
 c. 3  
 d. 4  
 e. Cannot be determined

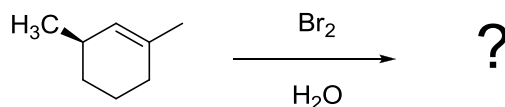
9. What reagent(s) would you use to carry out this transformation?



- a.  $\text{Hg}(\text{OAc})_2$  and  $\text{H}_2\text{O}$ , then  $\text{NaBH}_4$
  - b.  $\text{O}_3$ , then DMS
  - c.  $\text{O}_3$ , then  $\text{H}_2\text{O}_2$
  - d. *m*CPBA
  - e.  $\text{H}_3\text{O}^+$
10. A particular mechanistic step in a chemical reaction is exothermic. According to the Hammond postulate, the transition state for this step
- a. resembles the reactant in both structure and energy
  - b. resembles the product in both structure and energy
  - c. resembles the reactant structurally and the product energetically
  - d. resembles the reactant energetically and the product structurally
11. In this structure, what is the relationship between the groups P and Q?

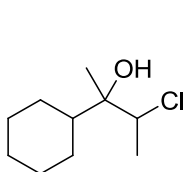
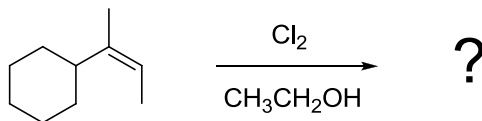


- a. gauche
  - b. anti
  - c. eclipsed
  - d. none of these
12. What is the stereochemical outcome of this reaction?

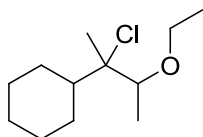


- a. diastereomers in unequal amounts
- b. diastereomers in equal amounts
- c. enantiomers in unequal amounts
- d. enantiomers in equal amounts
- e. a single chiral molecule

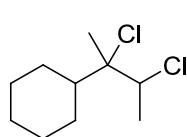
13. What is the major product of this reaction (not considering stereochemistry)?



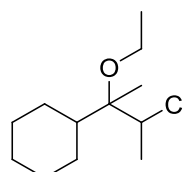
**A**



**B**



**C**

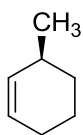


**D**

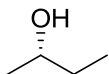
None of these is a product of this reaction

**E**

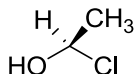
14. Select the molecule that has an *R* configuration at its asymmetric carbon.



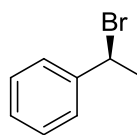
**A**



**B**



**C**

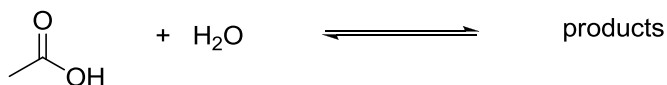


**D**

None of these has an absolute configuration of *R*

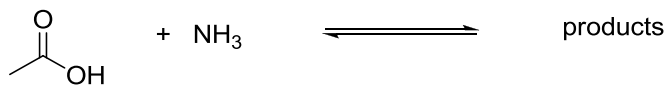
**E**

15. Identify the HOMO in the reaction between acetic acid and water.

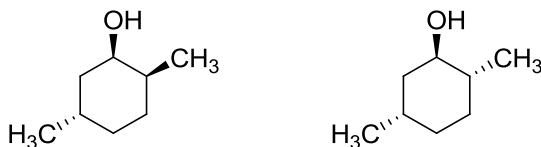


- OH  $\sigma$  in H<sub>2</sub>O
- OH  $\sigma^*$  in acetic acid
- $sp^3$  on O in H<sub>2</sub>O
- s in acetic acid
- None of these

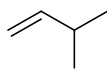
16. Estimate the equilibrium constant,  $K$ , for the reaction between ammonia and acetic acid. The  $pK_a$  of  $NH_4^+$  is 9. The  $pK_a$  of acetic acid is about 5.



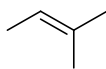
- a. 4  
b. -4  
c. 20  
d.  $10^{-4}$   
e.  $10^4$
17. Which word correctly describes the relationship between these two structures?



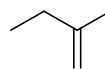
- a. constitutional isomers  
b. diastereomers  
c. enantiomers  
d. identical  
e. nonsensomers
18. Which of these alkenes would produce 2-methyl-2-butanol when treated with catalytic  $H_2SO_4$  and water?



**K**



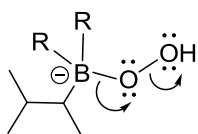
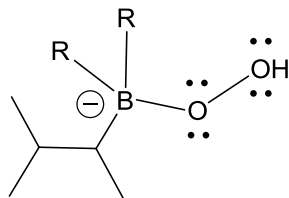
**L**



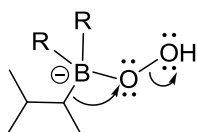
**M**

- a. K  
b. L  
c. M  
d. L or M  
e. K, L or M

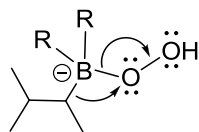
19. Shown below is a key intermediate in the oxidation step of hydroboration-oxidation. One of the bonds in this structure migrates to form a new intermediate. Which of the following structures has the correct curved arrow notation to show this bond migration?



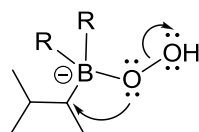
**A**



**B**



**C**



**D**

None of these choices is correct

**E**

20. Which of these cyclic molecules adopts a conformation that allows it to relieve torsional strain?



**W**



**X**



**Y**

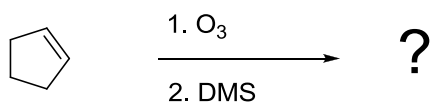
- W, X and Y
- W and X
- W and Y
- X and Y
- Y only

For Questions 21-24, the answer choices are:

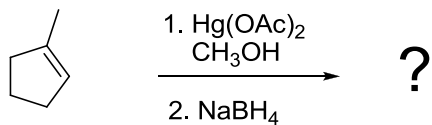
- A. Alcohol
- B. Ketone or Aldehyde
- C. Carboxylic acid
- D. Alkyl halide
- E. None of these (*i.e.*, the product is some other kind of molecule)

For each question, select the answer choice that best describes the product of the reaction conditions shown.

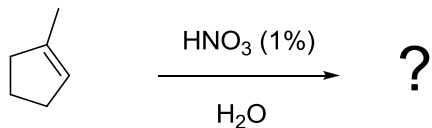
21.



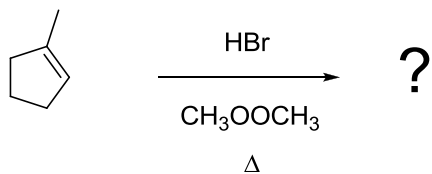
22.



23.

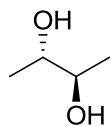


24.

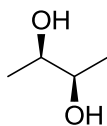




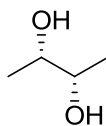
25. The Kardashians have a new reality show! It's called "The Kardashians Go Khiral", and it's sure to be a hit. The only problem is.... the Kardashians don't understand stereochemistry! For example, Kim thought all of the compounds shown below were optically active, but they are not. Which one of the following compounds is *optically inactive*?



**A**



**B**



**C**

Kim is right.  
All of these  
are optically  
active!

**D**