

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 8 printed pages, including this cover sheet. There are 21 questions, including 18 multiple choice questions. Be sure you have them all. Each multiple choice question is worth 4 points and has only one correct answer. Read each question carefully so that you know exactly what is being asked and what you need to write or draw. Your work on scratch pages will not be graded, so be sure everything you want graded is written on the exam itself. Good luck!

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VII B	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]						

Select the single best answer to each multiple choice question (1-18) and bubble it in on your Scantron. (4 pts each)

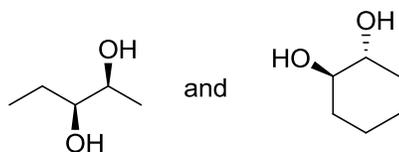
For questions 1-5, identify the correct relationship between the two molecules shown using one of the following choices:

- a. identical
- b. constitutional isomers
- c. diastereomers
- d. enantiomers
- e. none of these choices

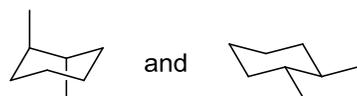
1.



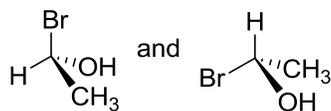
2.



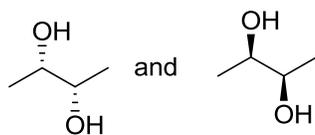
3.



4.



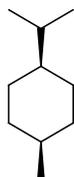
5.



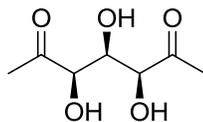
For questions 6-10, choose the term from the following list that correctly describes the structure:

- a. chiral
- b. achiral
- c. achiral and meso

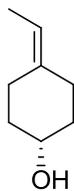
6.



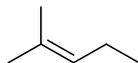
7.



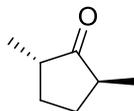
8.



9.



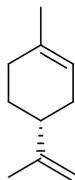
10.



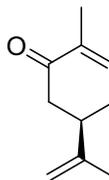
For questions 11 and 12, indicate whether the absolute configuration at the asymmetric carbon is *R* or *S* by choosing the correct option:

- a. *R*
b. *S*

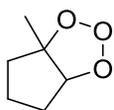
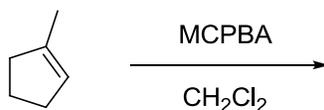
11.



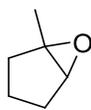
12.



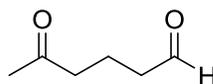
13. What is the major organic product of this reaction?



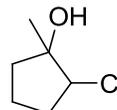
A



B



C



D

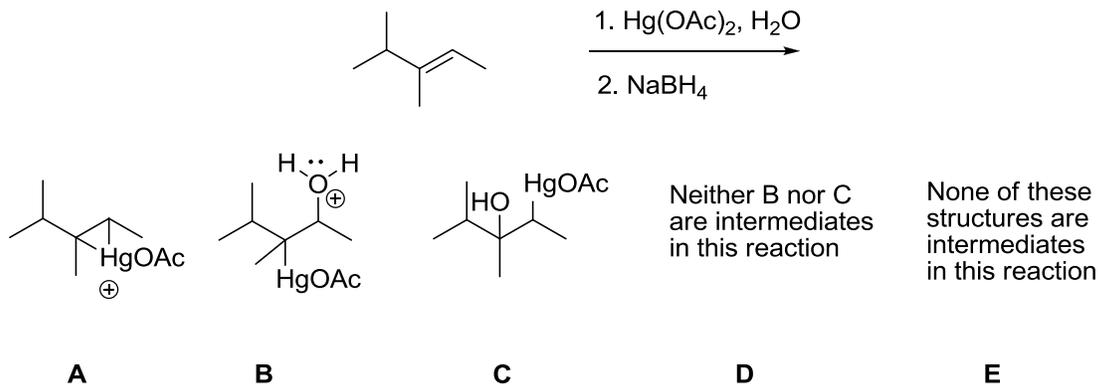
None of these
is the major
organic product

E

14. You have seen a number of addition reactions that can be classified as either “Markovnikov” or “anti-Markovnikov”. Which of the following reagents is *not* involved in creating an anti-Markovnikov product from an alkene?

- a. $\text{BH}_3\text{-THF}$
b. CH_3OOCH_3
c. $\text{Hg}(\text{OAc})_2$
d. H_2O_2
e. All of these reagents are involved in anti-Markovnikov processes.

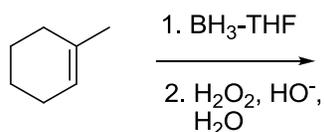
15. Which of the following is *not* a mechanistic intermediate in this reaction?



16. Which of the following terms or phrases does *not* describe meso compounds?

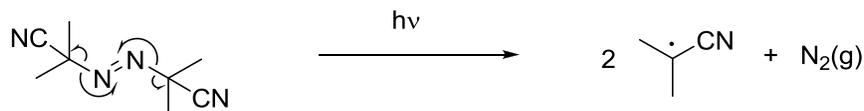
- They have asymmetric carbons
- They are achiral
- They have an internal (i.e., within the molecule) symmetry plane
- They are related to other compounds as diastereomers
- All of these statements properly describe meso compounds

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



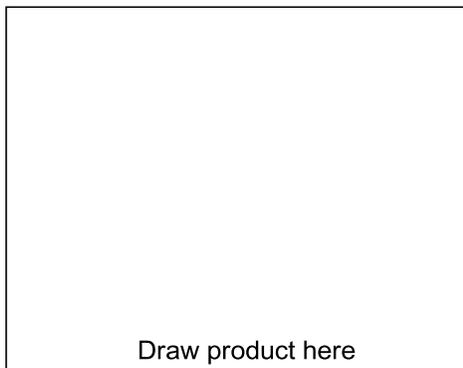
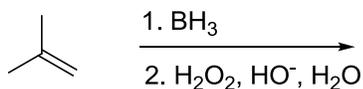
- oxidation
- reduction
- neither oxidation nor reduction

18. What type of mechanistic step is shown here?



- initiation
- propagation
- termination
- substitution
- chain reaction

19. Predict the major organic product of the following conditions and draw mechanisms as instructed below. In your mechanisms, show all necessary electrons (both lone pairs and unpaired electrons), non-zero formal charges, bonds, and curved arrows to receive full credit. (12 pts)

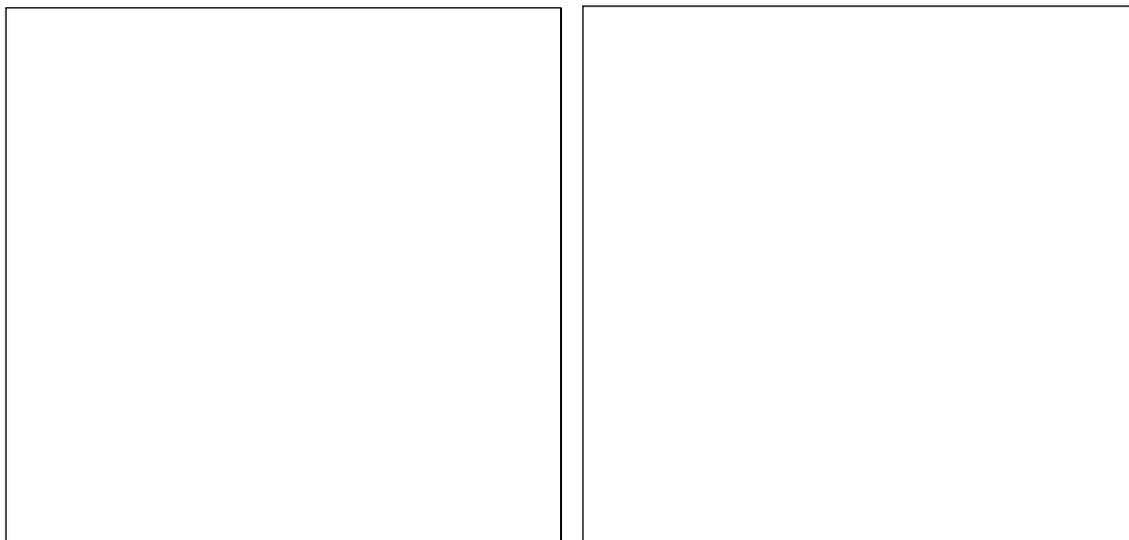


- (a) Draw the major organic product in the box to the right of the reaction arrow.
- (b) Draw a mechanism to show the addition of BH_3 across the alkene. You will recall that this process repeats three times. You only need to draw the first addition. Draw the structure of the trialkylborane that results from these three additions. Show all alkyl groups explicitly (i.e., do not abbreviate as "R").
- (c) Draw a mechanism showing the oxidation of the trialkylborane. You will recall that this process also repeats three times. You only need to draw the first oxidation. You may use the abbreviation "R" for alkyl groups not directly involved in the step you show (the involved alkyl group must be drawn explicitly).

20. READ THE FOLLOWING QUESTION CAREFULLY BEFORE YOU START DRAWING.

- (a) Draw the two chair conformations of 1,1,2-trimethylcyclohexane.
- (b) Clearly identify all sources of strain (i.e. gauche butane interactions) in each molecule. Under each chair, list the total number of gauche butane interactions you have identified.
- (c) Circle the more stable chair conformation.

Draw your chairs neatly and in accordance with the guidelines set forth in class and in the text. Draw every hydrogen that is attached to the ring. Abbreviate methyl groups as "Me" or "CH₃". Do not draw "bowtie pasta with hair". (12 pts)



Total number of gauche butanes in this chair = _____ Total number of gauche butanes in this chair = _____

21. Gas chromatography is an analytical technique that separates molecules based on their boiling points. In a typical experiment, a sample of a compound is injected into the chromatograph, where it passes through a column and a detector. Once it passes through the detector, a signal is generated that is recorded as a "peak" on chart paper.

A chemist injects a mixture of all of the stereoisomers of 1,2-dimethylcyclobutane into a gas chromatograph.

(a) Draw all the stereoisomers of 1,2-dimethylcyclobutane and indicate their relationships to each other (enantiomers or diastereomers). Make sure that your drawings and relationships are clearly labeled. (6 pts)

(b) How many peaks did the chemist see once this mixture had been separated? Explain. (6 pts)

Number of peaks = _____

Explanation (one or two sentences will be sufficient):