

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

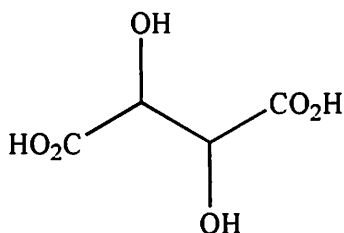
General Instructions: There are 12 pages, including this cover sheet. Be sure you have them all. Read each question carefully so that you know exactly what is being asked and what you need to write or draw. Your work on scratch pages will not be graded, so be sure everything you want graded is written on the exam itself. Good luck!

PERIODIC CHART OF THE ELEMENTS

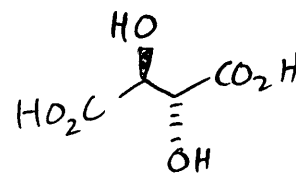
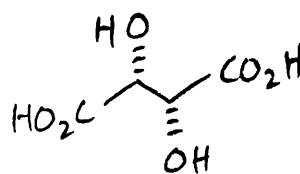
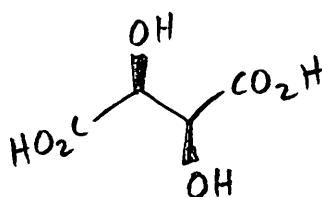
IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES		
1 H 1.00797														1 H 1.00797	2 He 4.0026		
3 Li 6.939	4 Be 9.0122										5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183	
11 Na 22.98976	12 Mg 24.312										13 Al 26.9815	14 Si 28.086	15 P 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 (1-15) and bubble it in on your Scantron. (4 pts each)

1. How many stereoisomers exist for this compound?



- a. 1
- b. 2
- c. 3
- d. 4
- e. 5



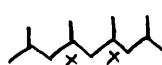
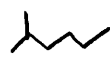
2. Which of the following statements is/are true?

- I. A racemic mixture is optically active.
- II. Diastereomers are nonsuperimposable mirror images.
- III. Meso compounds are achiral.

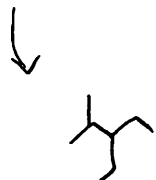
- a. I
- b. II
- c. III
- d. All are true.
- e. None are true.

3. Which of the following molecules could be chiral?

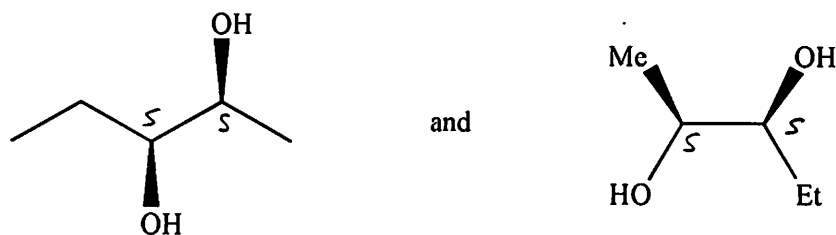
- a. 2-methylhexane
- b. 3-methylpentane
- c. 2,4,6,8-tetramethylnonane
- d. 2,3,4-trimethylpentane
- e. 3-ethyl-2-methylpentane



x's show asymmetric C's



4. Which term best describes the relationship between the molecules shown?



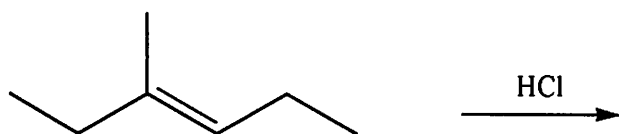
- a. constitutional isomers
- b. diastereomers
- c. enantiomers
- d. identical
- e. structural isomers

5. Which of the following statements about this structure is *true*?

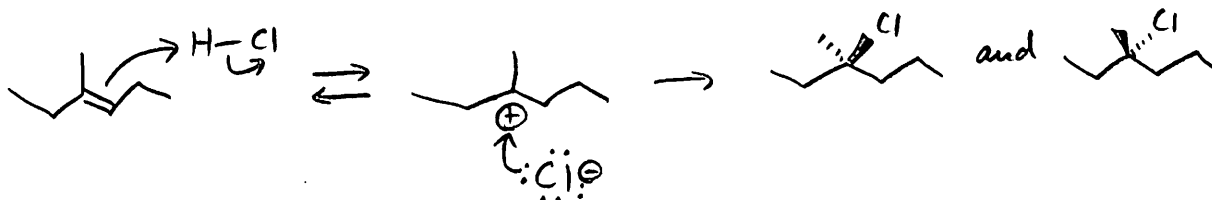


- ~~a.~~ The two methyl groups are anti.
- b. The two methyl groups are gauche.
- ~~c.~~ The two methyl groups are eclipsed.
- d. The conformation shown is the highest energy conformation for this molecule. *Lowest*

6. Which of the following statements is *true* about the reaction shown here?



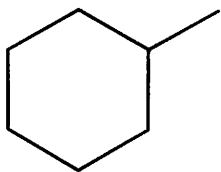
- a. The products are diastereomers, formed in unequal amounts.
- b. The products are diastereomers, formed in equal amounts.
- c. The products are enantiomers, formed in unequal amounts.
- d. The products are enantiomers, formed in equal amounts.
- e. The products are structural isomers, formed in unequal amounts.



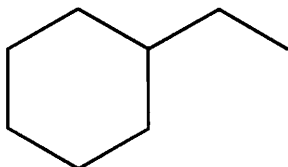
Cl⁻ approaches from either face of planar cation with equal probability

7. For which of the following do you expect there to be the greatest percentage of molecules in the conformation with the substituent in an equatorial position?

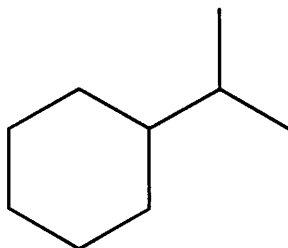
a.



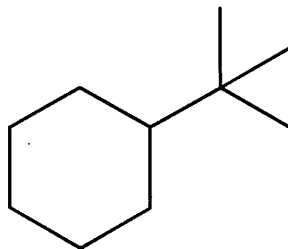
b.



c.



d.

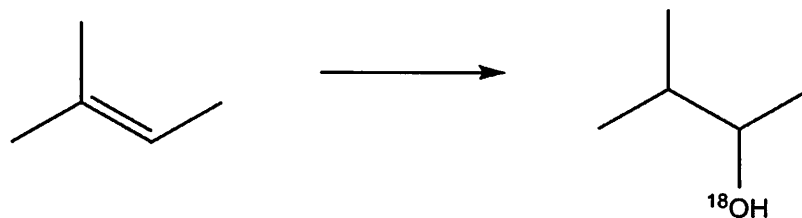


Largest alkyl group has largest preference to be equatorial

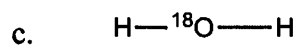
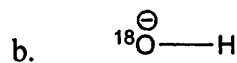
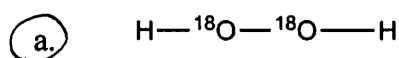
8. Which of these processes is a *syn* addition?

- a. Hydration of an alkene using water and catalytic sulfuric acid.
- b. Addition of HCl to an alkene.
- c. Addition of Cl₂ to an alkene.
- d. Hydroboration-oxidation of an alkene.
- e. Both a and b.

9. An anti-Markovnikov hydration of an alkene was performed as shown here, and one of the reagents used for this reaction was labeled with an isotope of oxygen, ^{18}O . This labeled oxygen ends up in the product as shown.

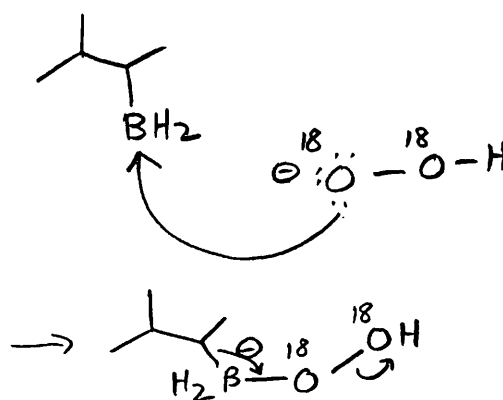


Which of the following choices correctly shows which reagent had the labeled oxygen?

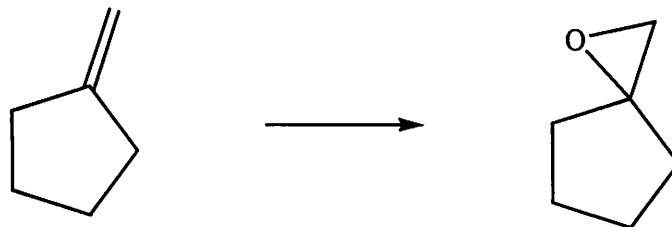


d. Either b or c.

e. Any of these is correct.

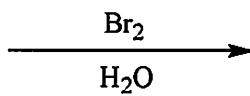
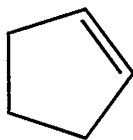


10. Which reagent(s) would you use to accomplish this transformation?

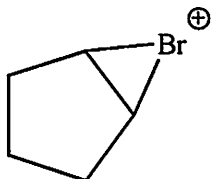


- a. $\text{Br}_2/\text{H}_2\text{O}$
 b. $\text{Hg}(\text{OAc})_2$ and H_2O , then NaBH_4 and OH^-
 c. MCPBA
 d. $\text{HO}^-/\text{H}_2\text{O}$
 e. $\text{H}_3\text{O}^+/\text{H}_2\text{O}$

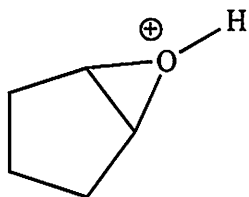
11. Which of these structures is an intermediate in this transformation?



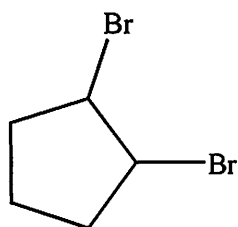
a.



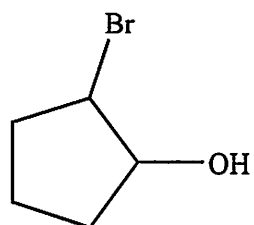
b.



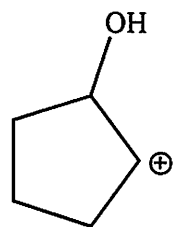
c.



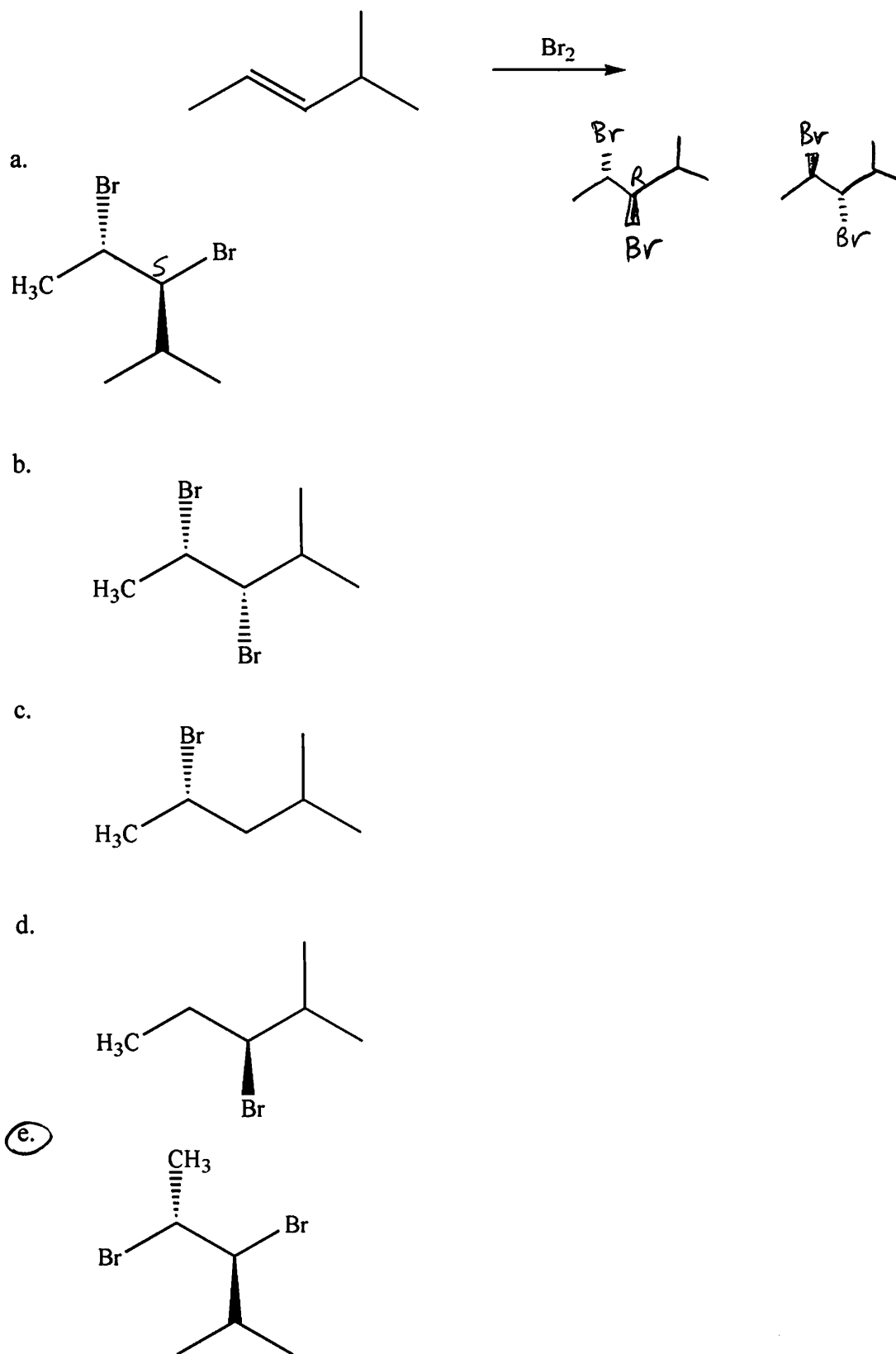
d.



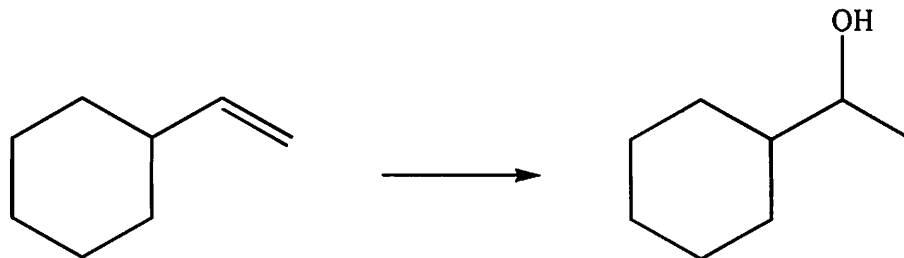
e.



12. Which of these molecules is a product of the reaction shown?



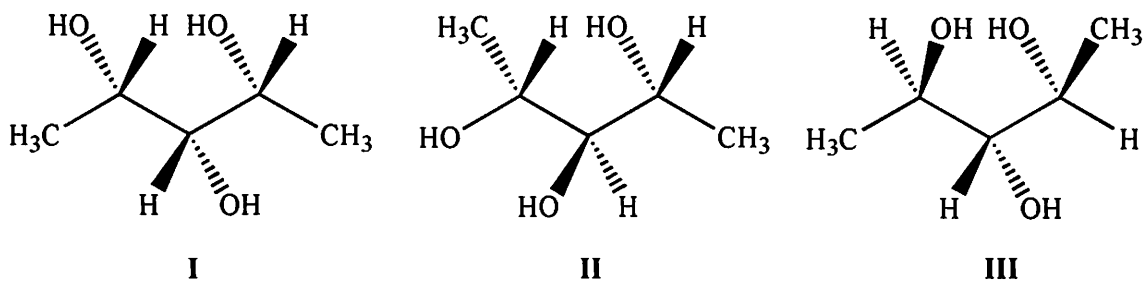
13. Which reagent(s) would you use to accomplish this transformation?



- a. $\text{H}_2/\text{Pd on C}$
- b. $\text{BH}_3 \cdot \text{THF}$, then H_2O_2 , OH^- , H_2O
- c. $\text{Hg}(\text{OAc})_2$, H_2O , then NaBH_4 and OH^-
- d. Catalytic HNO_3 and H_2O
- e. O_3 , then H_2O_2

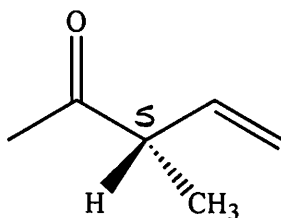
would rearrange and not provide product shown

14. Which of the following molecules is/are chiral?



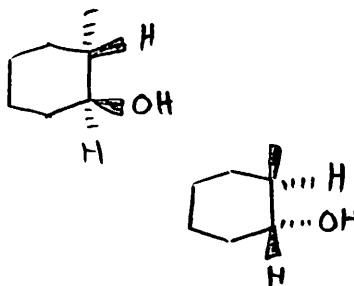
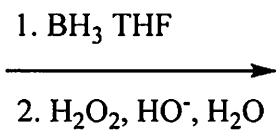
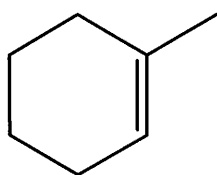
- a. I
- b. II
- c. III
- d. I and III
- e. II and III

15. Assign the absolute configuration at the asymmetric carbon in this molecule as *R* or *S*.



- a. *R*
- b. *S*

16. Draw the products of each of the reactions shown. Show stereochemistry in your drawings. Then indicate the relationship between the products and their relative amounts by circling the correct choice in the answer box. (12 pts)

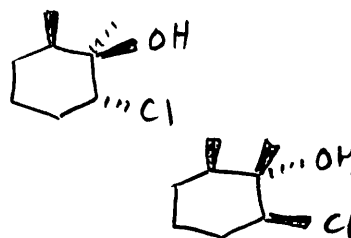
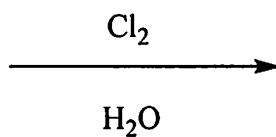
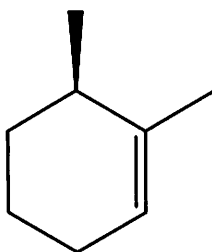


enantiomers - equal amounts

enantiomers - unequal amounts

diastereomers - equal amounts

diastereomers - unequal amounts



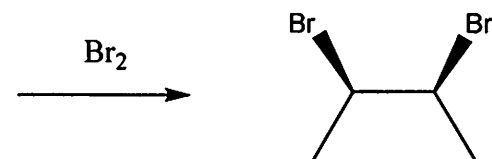
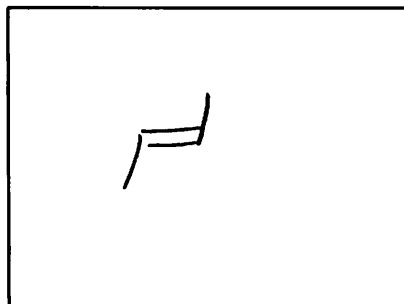
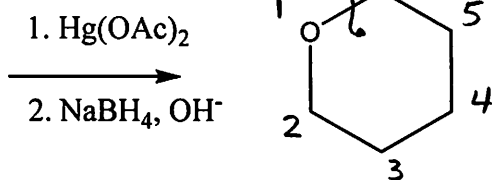
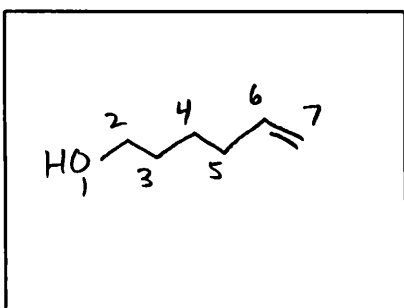
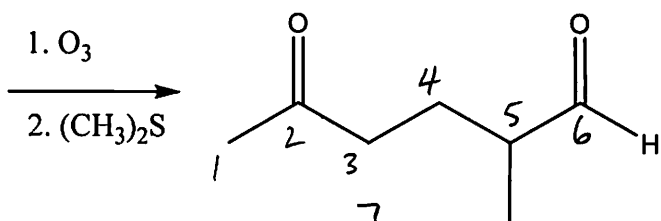
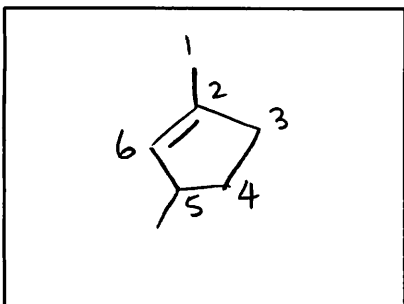
enantiomers - equal amounts

enantiomers - unequal amounts

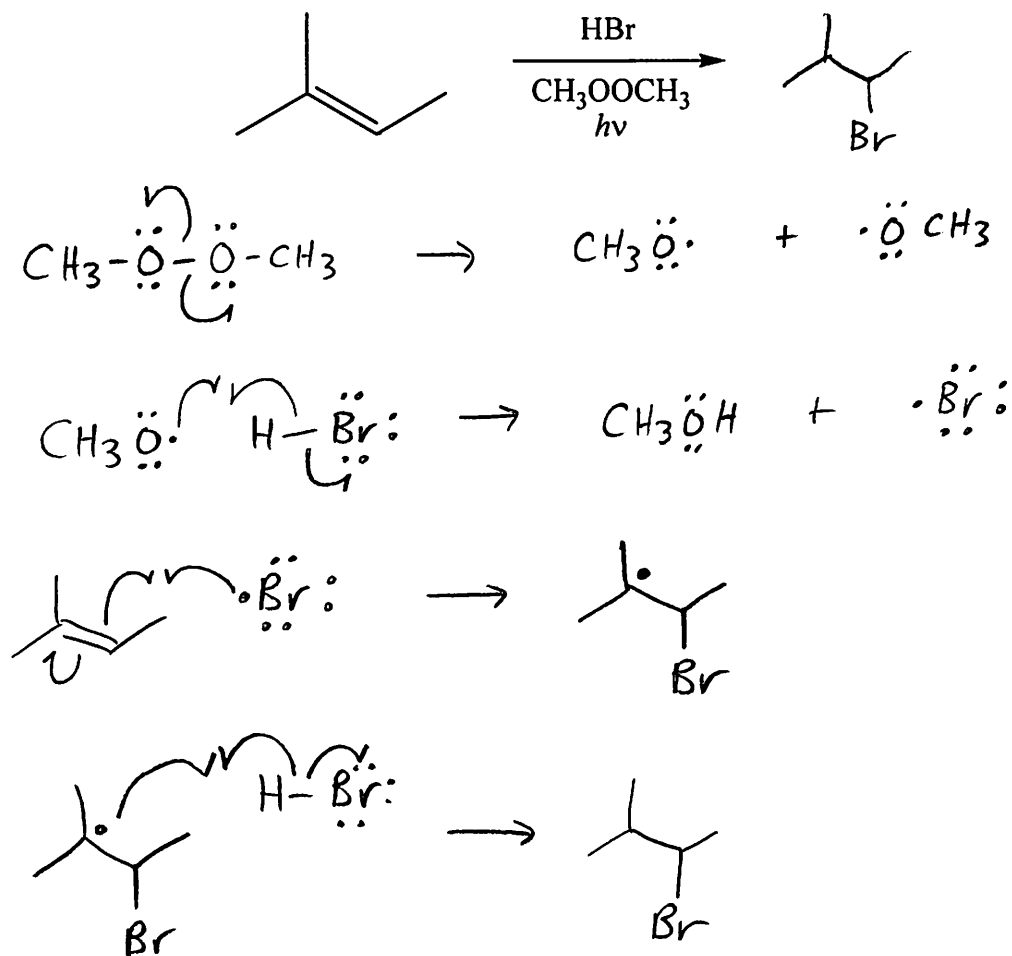
diastereomers - equal amounts

diastereomers - unequal amounts

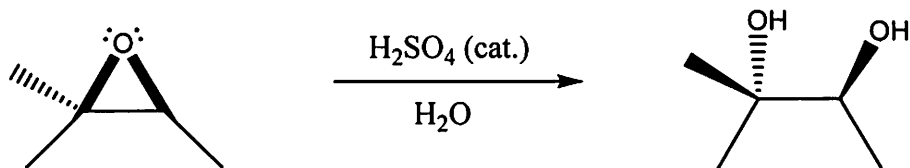
17. Draw the structure of the starting material for each of the reactions shown. (12 pts)



18. Predict the major organic product of the reaction conditions shown and draw a mechanism to show how it is formed. For full credit, include all lone pairs of electrons, single electrons, non-zero formal charges and curved arrows. (10 pts)



19. The epoxide shown is transformed to a structure called a *vicinal diol* (OH groups on adjacent carbons) in aqueous sulfuric acid:



Although you have not yet seen this reaction, the mechanism involves patterns you know. Propose a mechanism for this transformation. (6 pts)

