

*Please read the following before proceeding*

1. Materials: Turn off cell phones and wireless PDA devices. Place all other materials on the floor. You will only need a pencil. Molecular models are optional.
2. Show your Buzz Card when you turn in your completed exam.
3. You must work alone.
4. This is a closed book exam. Give or take no assistance from other students. Recall the Georgia Tech Honor Code.

*"I have always worked better alone."-- Claude Monet*

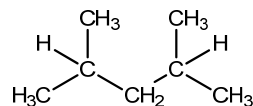
"I pledge my honor that I have not violated the Honor Code during this examination."

Signed \_\_\_\_\_

**Note: A pKa table is provided on the last page.**

**1. (40 points, 4 points each) Circle the correct answer. There is only one correct answer.**

- a. How many alkyl chlorides can be obtained from monochlorination of the following alkane?

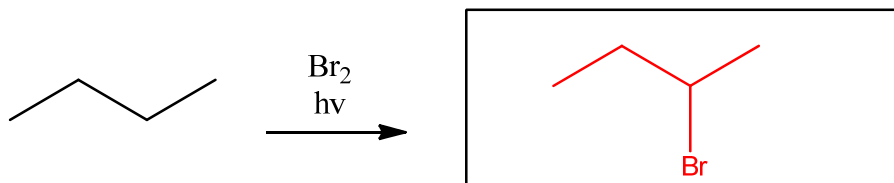


- A) 1  
B) 2  
**C) 3**  
D) 6
- b. What is the major product obtained from the monobromination of 2,2,6-trimethylheptane?
- A) 2-bromo-2,6,6-trimethylheptane**  
B) 4-bromo-2,2,6-trimethylheptane  
C) 2-bromo-2,2,6-trimethylheptane  
D) 1-bromo-2,6,6-trimethylheptane  
E) 3-bromo-2,2,6-trimethylheptane
- c. Which structure has the poorest leaving group?
- A) R-SH  
**B) R-NH<sub>2</sub>**  
C) R-OH  
D) R-Br
- d. What product will be formed from the reaction of *trans*-1-bromo-4-methylcyclohexane with methoxide ion under S<sub>N</sub>2 conditions?
- A) *trans*- and *cis*-4-methylcyclohexanol  
B) *trans*-4-methylcyclohexanol  
C) *trans*-1-methoxy-4-methylcyclohexane  
**D) *cis*-1-methoxy-4-methylcyclohexane**  
E) *trans*- and *cis*-1-methoxy-4-methylcyclohexane
- e. Which of the following alkyl halides is the most reactive in an S<sub>N</sub>2 reaction?
- A) 1-bromo-2-methylbutane  
B) 2-bromopropane  
C) 1-chlorobutane  
D) 1-bromo-2-methylpropane  
**E) 1-bromopropane**

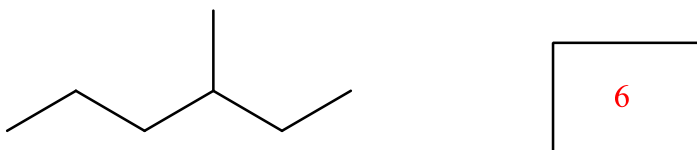
- f. Which statement best describes a carbon-oxygen bond?
- A) The bond is covalent and polar, with oxygen carrying a partial negative charge.
  - B) The bond is covalent and nonpolar.
  - C) The bond is ionic and polar, with oxygen carrying a full positive charge.
  - D) The bond is covalent and polar, with oxygen carrying a partial positive charge.
  - E) The bond is ionic and polar, with oxygen carrying a full negative charge.
- g. Which of the following compounds has the best leaving group?
- A) an ether
  - B) an amine
  - C) an alcohol
  - D) a protonated amine
  - E) a protonated alcohol
- h. Which of the following is **not** a true statement?
- A) Tertiary alcohols undergo  $S_N1$  reactions with hydrogen halides.
  - B) Primary alcohols undergo  $S_N2$  reactions with hydrogen halides.
  - C) Secondary alcohols undergo  $S_N1$  reactions with hydrogen halides.
  - D) Tertiary alcohols undergo E2 dehydration reactions.
  - E) Secondary alcohols undergo E1 dehydration reactions.
- i. Which of the following anions is the strongest base?
- A) fluoride ion ( $F^-$ )
  - B) acetate ion ( $CH_3CO_2^-$ )
  - C) iodide ion ( $I^-$ )
  - D) hydroxide ion ( $OH^-$ )
  - E) carbonate ion ( $CO_3^{2-}$ )
- j. What compound is formed when ethanol is treated with pyridinium chlorochromate (PCC) in dry methylene chloride solvent?
- A) acetic acid ( $CH_3CO_2H$ )
  - B) acetaldehyde ( $CH_3CHO$ )
  - C) ethyl chloride ( $CH_3CH_2Cl$ )
  - D) Acetone ( $CH_3COCH_3$ )
  - E) Ethane ( $CH_3CH_3$ )

2. (40 points, 4 points each) **SHORT ANSWER.** Draw the structure, or write the word or phrase that best completes each statement or answers the question.

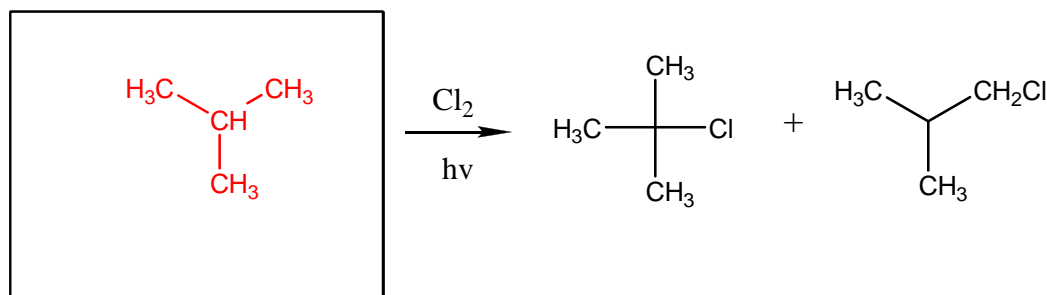
a. What is the product of the following reaction?.



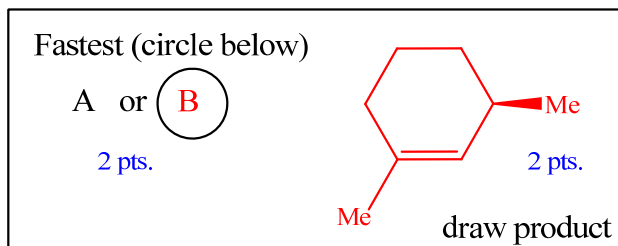
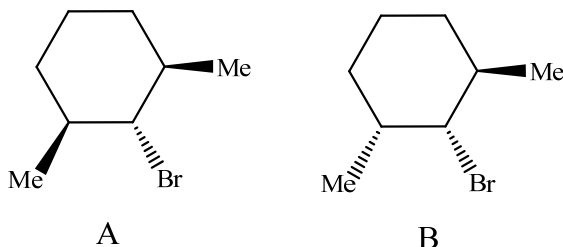
b. How many secondary hydrogen atoms are in the following compound?



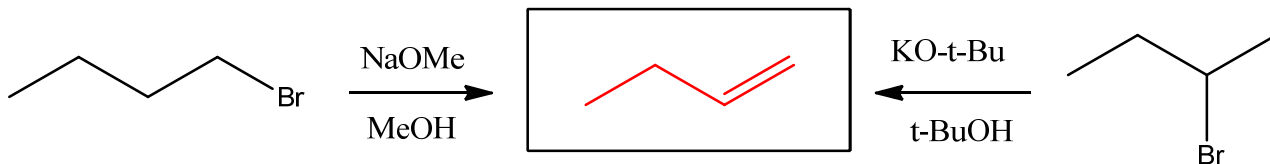
c. What is the starting reactant for the following reaction?



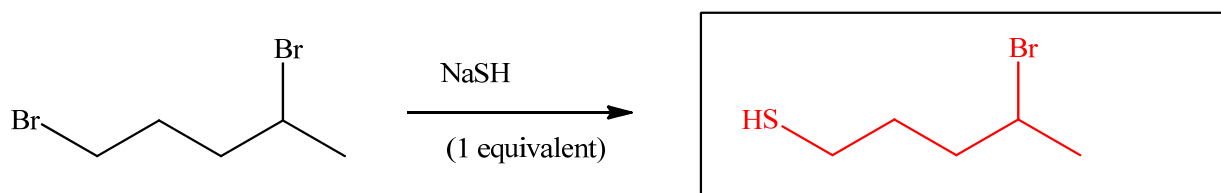
d. Which halide will react more rapidly by an E2 mechanism?



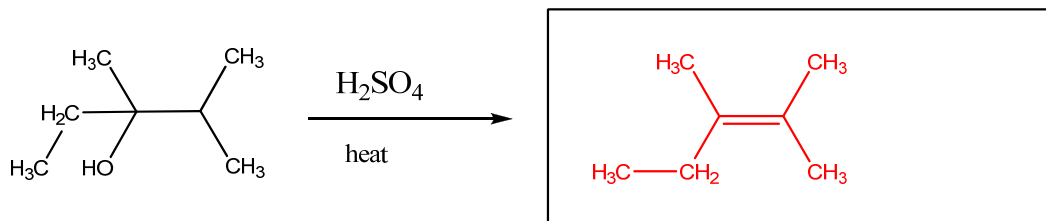
e. Draw the common product from the following two elimination reactions?



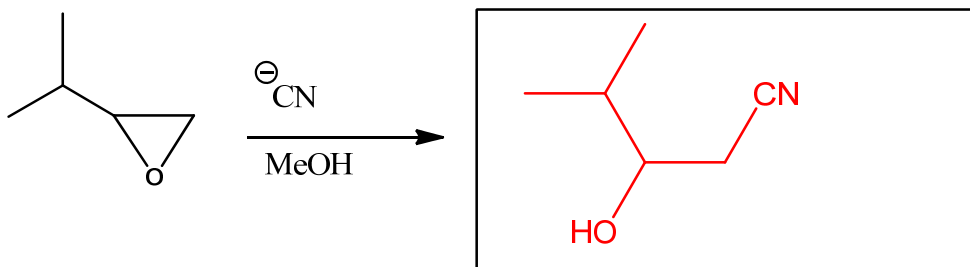
f. Draw the structure of the major product of the following  $S_N2$  reaction.



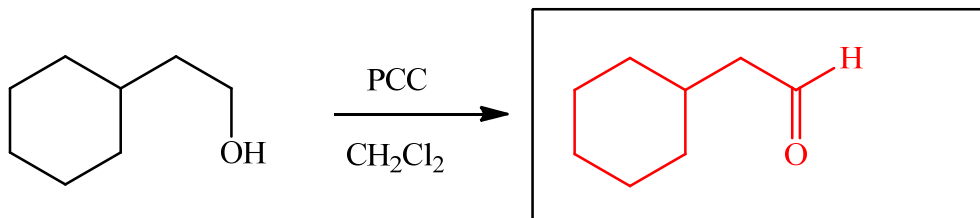
g. Draw the major product for the following reaction



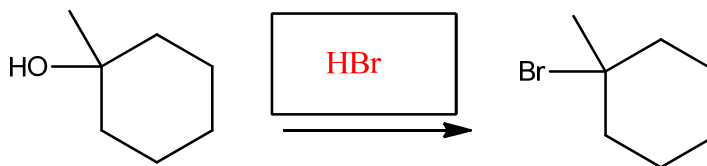
h. What is the product of the following reaction under basic conditions?



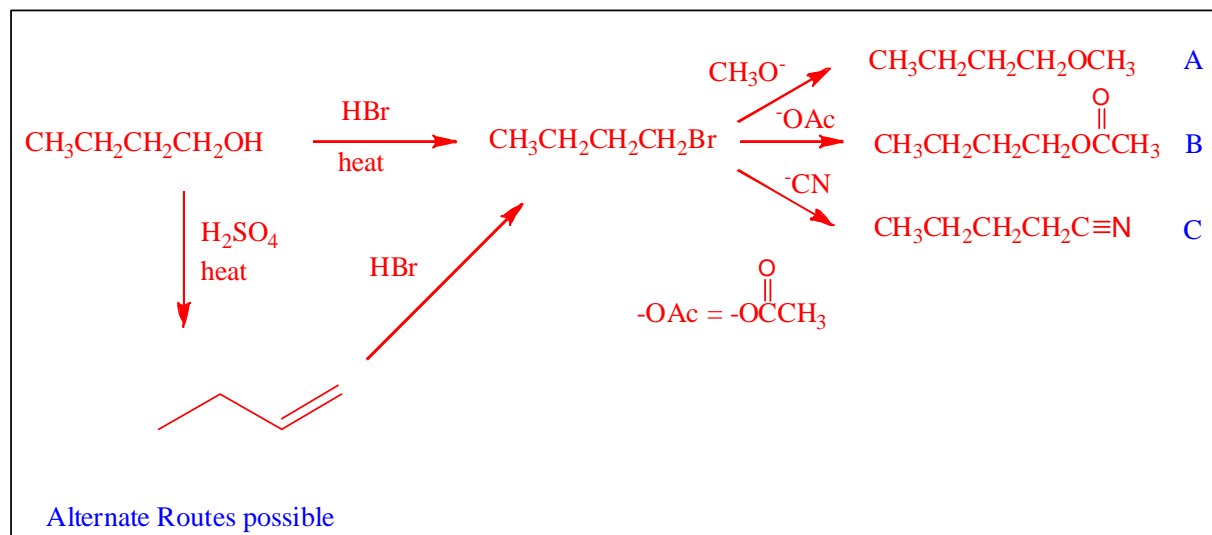
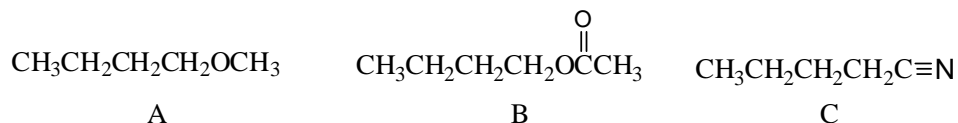
i. Draw the organic product for the following reaction.



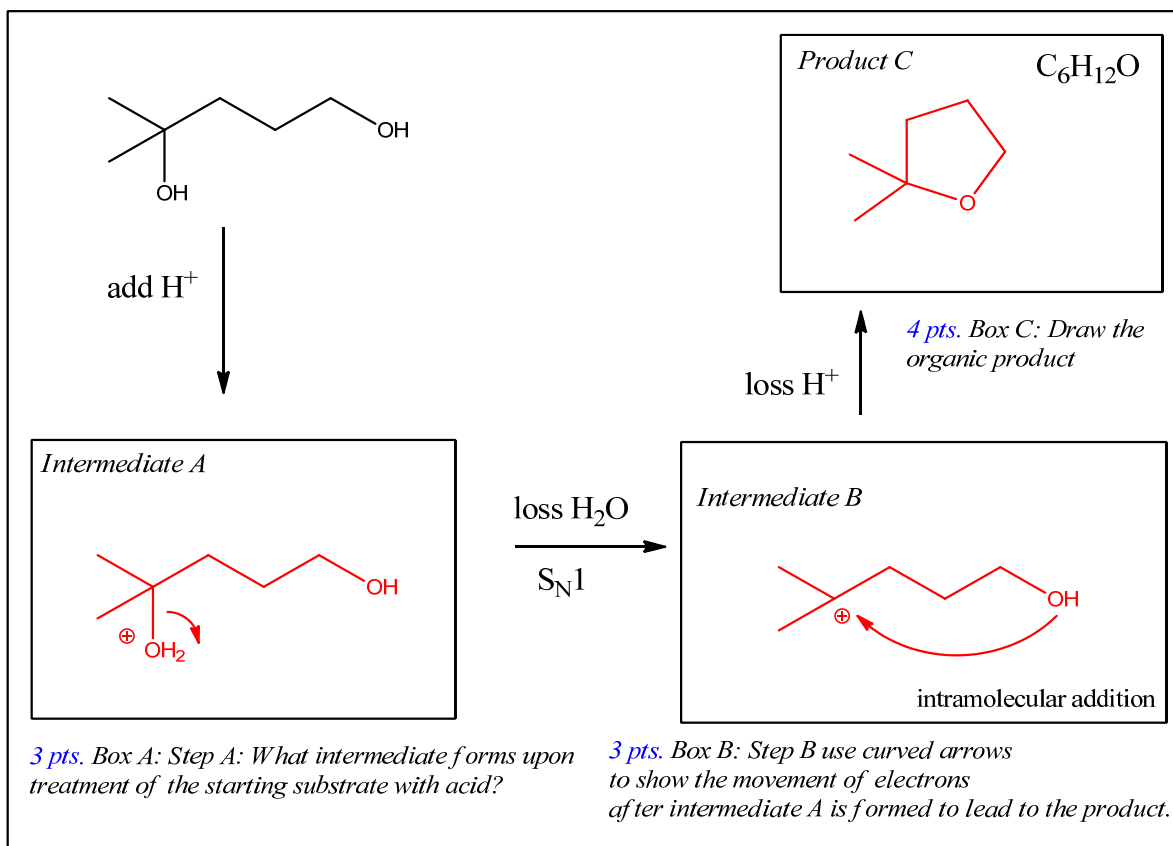
j. Draw the organic product for the following reaction.



3. (10 points) **Multistep synthesis:** Select one of the following three products. Show how **1-butanol** can be converted into any **ONE** of the following compounds. Provide a sequence of reactions to perform the transformation, showing the reagents and structures of all intermediate products. The synthesis must use the given starting material. You may use any other substrate materials and/or reagents. ***Do not draw the mechanistic steps.***



4. (10 points) ) **Mechanistic Understanding:** Using curved arrows, provide a stepwise mechanism for the reaction of the following diol (4-methyl-1,4-pentandiol) to form a  $C_6H_{12}O$  product. Also draw the product of the reaction.



Acid	Approximate $pK_a$	Conjugate Base
$\text{HSbF}_6$	$< -12$	$\text{SbF}_6^-$
$\text{HI}$	$-10$	$\text{I}^-$
$\text{H}_2\text{SO}_4$	$-9$	$\text{HSO}_4^-$
$\text{HBr}$	$-9$	$\text{Br}^-$
$\text{HCl}$	$-7$	$\text{Cl}^-$
$\text{C}_6\text{H}_5\text{SO}_3\text{H}$	$-6.5$	$\text{C}_6\text{H}_5\text{SO}_3^-$
$(\text{CH}_3)_2\text{OH}^+$	$-3.8$	$(\text{CH}_3)_2\text{O}$
$(\text{CH}_3)_2\text{C}=\text{OH}^+$	$-2.9$	$(\text{CH}_3)_2\text{C}=\text{O}$
$\text{CH}_3\text{OH}_2^+$	$-2.5$	$\text{CH}_3\text{OH}$
$\text{H}_3\text{O}^+$	$-1.74$	$\text{H}_2\text{O}$
$\text{HNO}_3$	$-1.4$	$\text{NO}_3^-$
$\text{CF}_3\text{CO}_2\text{H}$	$0.18$	$\text{CF}_3\text{CO}_2^-$
$\text{HF}$	$3.2$	$\text{F}^-$
$\text{CH}_3\text{CO}_2\text{H}$	$4.75$	$\text{CH}_3\text{CO}_2^-$
$\text{H}_2\text{CO}_3$	$6.35$	$\text{HCO}_3^-$
$\text{CH}_3\text{COCH}_2\text{COCH}_3$	$9.0$	$\text{CH}_3\text{COCHCOCH}_3^-$
$\text{NH}_4^+$	$9.2$	$\text{NH}_3$
$\text{C}_6\text{H}_5\text{OH}$	$9.9$	$\text{C}_6\text{H}_5\text{O}^-$
$\text{HCO}_3^-$	$10.2$	$\text{CO}_3^{2-}$
$\text{CH}_3\text{NH}_3^+$	$10.6$	$\text{CH}_3\text{NH}_2$
$\text{H}_2\text{O}$	$15.7$	$\text{OH}^-$
$\text{CH}_3\text{CH}_2\text{OH}$	$16$	$\text{CH}_3\text{CH}_2\text{O}^-$
$(\text{CH}_3)_3\text{COH}$	$18$	$(\text{CH}_3)_3\text{CO}^-$
$\text{CH}_3\text{COCH}_3$	$19.2$	$^-\text{CH}_2\text{COCH}_3$
$\text{HC}\equiv\text{CH}$	$25$	$\text{HC}\equiv\text{C}^-$
$\text{H}_2$	$35$	$\text{H}^-$
$\text{NH}_3$	$38$	$\text{NH}_2^-$
$\text{CH}_2=\text{CH}_2$	$44$	$\text{CH}_2=\text{CH}^-$
$\text{CH}_3\text{CH}_3$	$50$	$\text{CH}_3\text{CH}_2^-$

Write your class roll number on (1) the top of the first page and (2) below.

\*\*\*\*\* If you need to verify your class roll number, you can do this at the front of the room when you turn in your exam paper. \*\*\*\*\*

Roll Number \_\_\_\_\_

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Total 100 \_\_\_\_\_