Your full signature_____

Print your full name_____

Your SID_____

If you are **making up an I grade**

Indicate the semester you took the course _____

Name of the instructor for that course:_____

This exam has **15** pages; **make sure that you have them all.**
Page 15 has no question on it, it may be detached and used for scratch work.

We will only grade answers that are in the designated spaces. Write only **one** answer to each problem; multiple answers will receive **no** credit, even if one of them is correct.
Simple calculators are allowed.

Note: This examination runs for a total of **180 minutes**. No questions will be answered by proctors after the exam begins. Please write legibly; **ambiguous, faint, or messy answers will receive no credit**.

Do not write in this box.
1. _____ (16)
2. _____ (18)
3. _____ (15)
4. _____ (15)
5. _____ (15)
6. _____ (14)
7. _____ (21)
8. _____ (15)
9. _____ (14)
10. _____(15)
11. _____(15)
12. _____(11)
13. _____(16)
Total _____(200)

Partial periodic table of the elements

| IA							O
1 H 1.00794	IIA	IIIA	IVA	VA	VIA	VIIA	2 He 4.00260
3 Li 6.941	4 Be 9.01218	5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80

1) 16 Points

(a) What is the degree of unsaturation of $C_8H_7NO_2$?   Answer:

(b) A hydrocarbon containing eight C atoms was found to have two degrees of unsaturation but no absorption band in the IR spectrum at 1640 cm^{-1} Circle the structure below that best fits this description.

$CH_3(CH_2)_6CH_3$
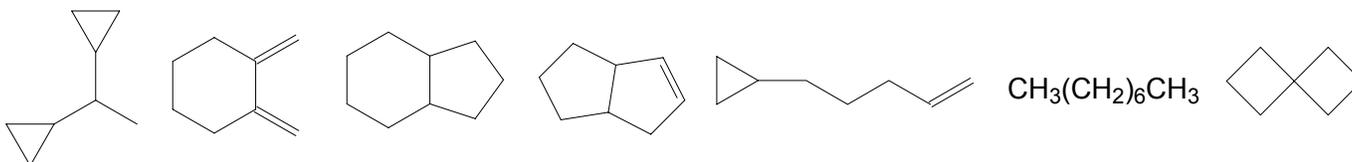
(c) A sample of optically pure compound weighing 4g was dissolved to afford 20mL of solution. The optical rotation of this solution measured in a 10cm polarimeter tube was 16°
What is the specific rotation of the compound? Show your calculation and circle one answer below.

0.8^o 1.6^o 3.2^o 8° 16° 32° 40° 60° 64° 80° 120° 160°

(d)   Name the **drug** discussed in class used in the treatment of Parkinson's disease.

Answer:

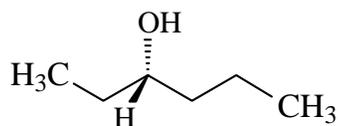(e) How many stereoisomers are possible for each of the compounds below
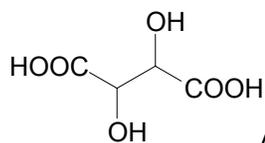
Answer:
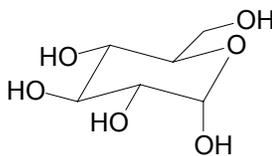
Answer:
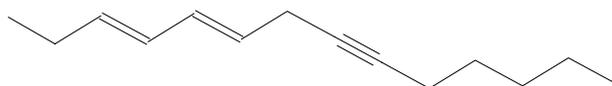
Answer:
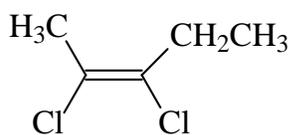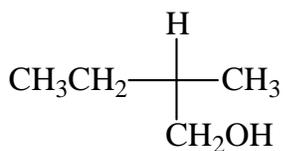
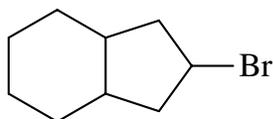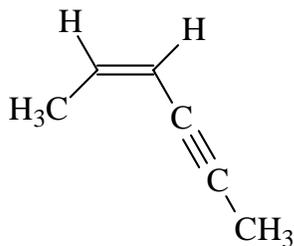**2.   18 Points.** Name the following compounds (IUPAC nomenclature)
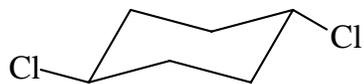
shown as a Fischer projection

3. 15 Points. Write a clear structure for each of the following compounds (show stereochemistry where appropriate!)

Trans-3-chlorocyclopentanol

(E)-3-bromo-2-hexene

(1R,2R)-2-(2-hydroxyethyl)-
 cyclopentanol

2-methyloxacyclobutane

1,4-hexadiyne

4. 15 points.

(a) The boiling point of the 1,2-dichloroethene stereoisomers ClCH=CHCl are 47 and 60°C. Show a clear stereochemical representation of each of the two stereoisomers and circle the structure of the stereoisomer with the highest boiling point. Explain your answer.

Explanation:

(b) The reaction of cyclopropane with chlorine (Cl_2) in the presence of light is known to produce 1,3-dichloropropane. Write an overall equation for this process and show a step by step mechanism for the formation of this unexpected product. Calculate the change in enthalpy for this reaction

Bond Dissociation Energies:

Cl—Cl   58 Kcal mole^{-1}

RCH_2—Cl   81 Kcal mole^{-1}

CH_2 / H_2C—CH_2 65 Kcal mole^{-1}
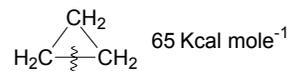
(**Answer**) Change in Enthalpy =

5. 15 Points.

The electrophilic addition of HCl to propene could, in principle, lead to two different products 1-chloropropane and 2-chloropropane. Build a **fully labeled energy diagram** clearly showing the two reactions pathways (do not forget to show the different energy levels, transition states, structure and location of intermediates, structure and location of starting materials and products, etc.) and explain why only one of the two possible products is obtained.
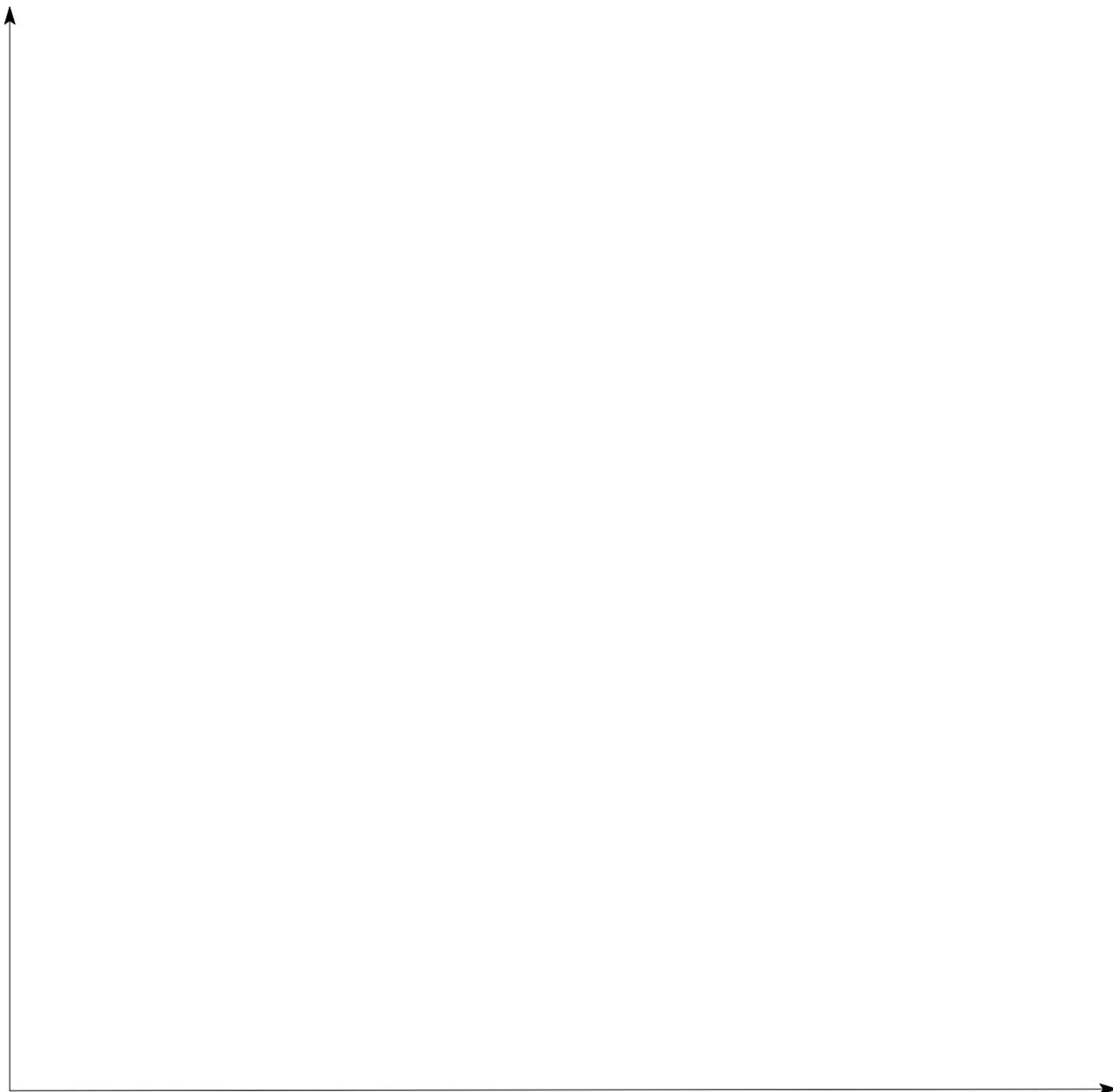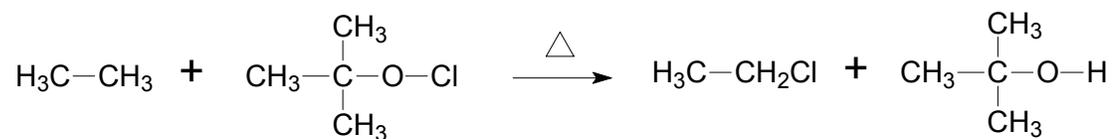
Explanation:

The only product obtained is _____ *because:*

6. 14 Points.

(a) Propose a mechanism for the following reaction with ΔH° = - 42 Kcal mole^{-1}

$$H_3C-CH_3 \ + \ CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-O-Cl \ \xrightarrow{\triangle} \ H_3C-CH_2Cl \ + \ CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-O-H$$

(b) Given the following bond dissociation energies C—H 101 Kcal mole^{-1} C—Cl 82 Kcal mole^{-1} and O—H 102 Kcal mole^{-1} **calculate** the bond dissociation energy of the O—Cl bond. Show the details of your calculation.

Answer: Bond dissociation Energy =

7. 21 Points Complete the reactions below showing all the missing reagents. If more than one step is involved, number them, show the reagents for the first step above the arrow and those for the next step(s) below the arrow. The reagents chosen must be such that the product shown is the major product of the reaction.
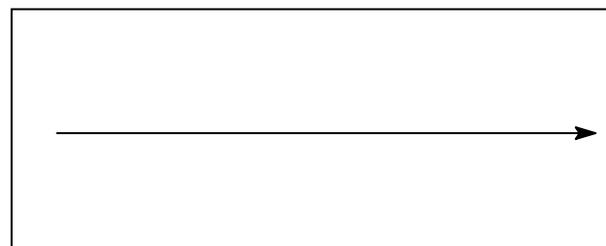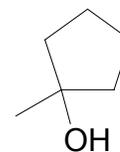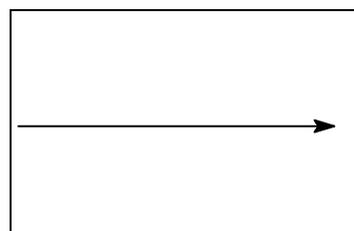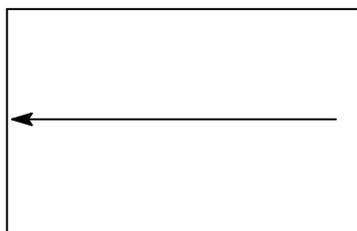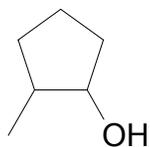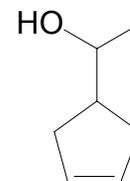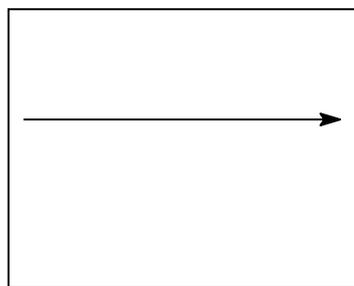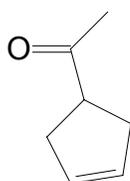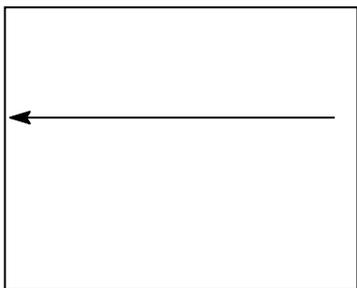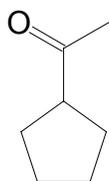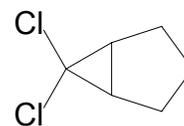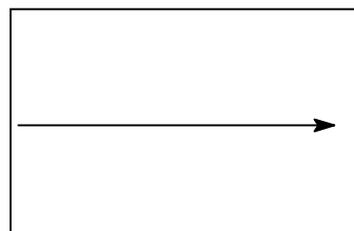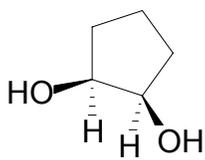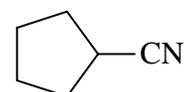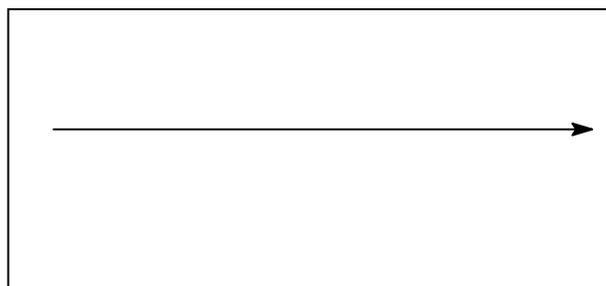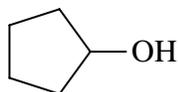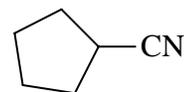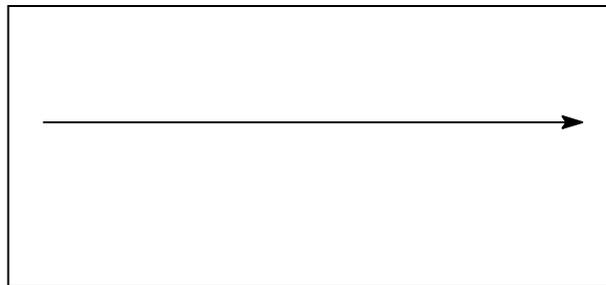
8.   15 Points. Complete the following equations by showing the structure of the product(s) obtained (show stereochemistry where relevant).

$H_3C-C\equiv C-CH_3$ + 1 Br_2 ⟶

Br$_2$ + H$_2$O

1) O$_3$

2) CH$_3$SCH$_3$

1)

‌MgBr

2) aqueous work-up

H$^+$/H$_2$O

O◁

CH$_3$

OH

H$^+$ H$_2$O

C≡C—H

HgSO$_4$
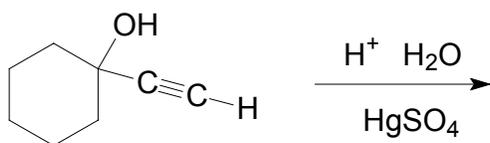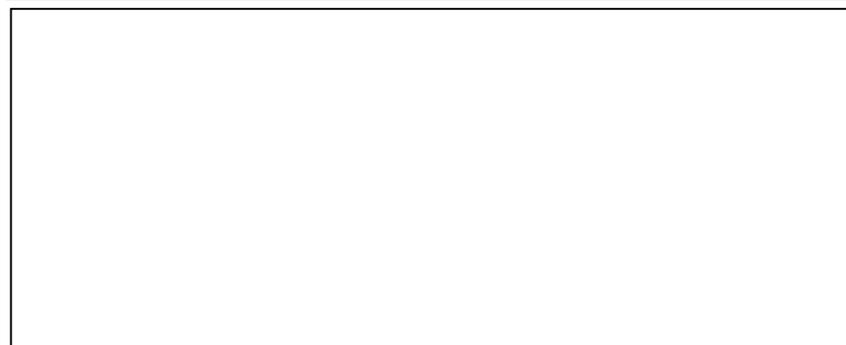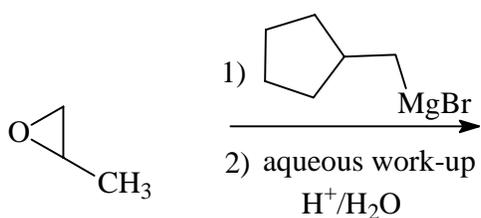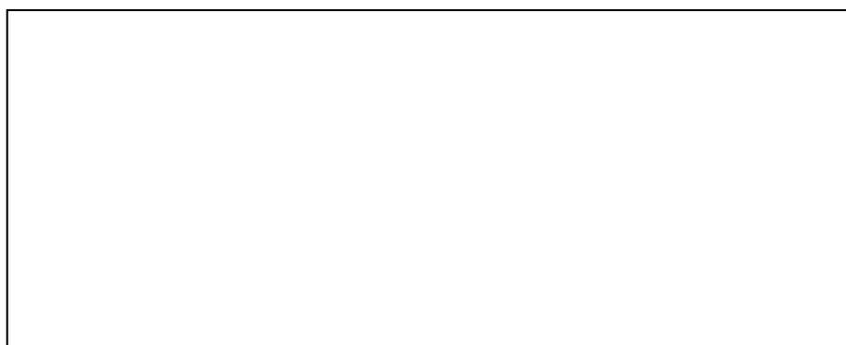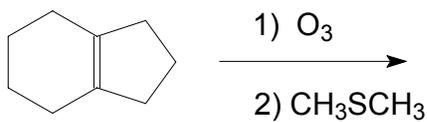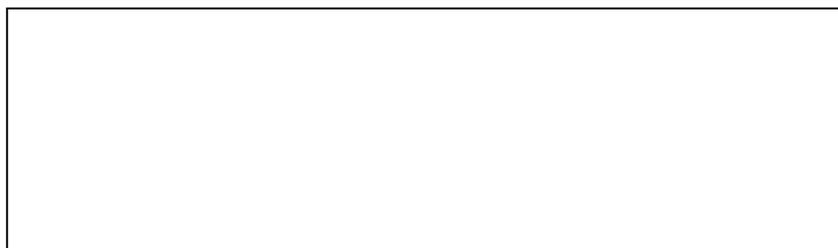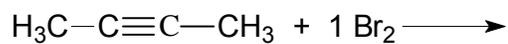
9. 14 Points.
Propose a step-by-step synthesis of the following compounds from the starting material(s) indicated. Show all reagents (& solvents where relevant) for each step. No mechanism is needed.

(a) $CH_3-C\equiv C-CH_3$ from $CH_3CH_2CH_2CH_3$

(b) $H_3C-\underset{\underset{D}{|}}{CH}-CH_3$ from $H_2\underset{\underset{Br}{|}}{C}-CH_2-CH_3$ (note that D is deuterium or ^2H)
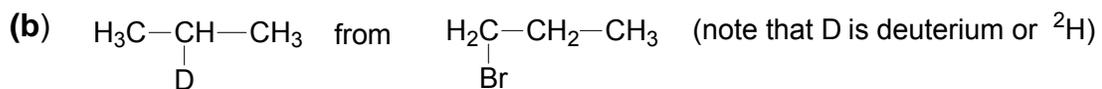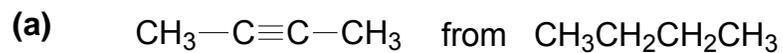
10. 15 Points The mass spectrum of $(CH_3)_2CHCH_2CH_3$ shows a small molecular ion at m/z = 72 as well as a very small peak at m/z = 73. **(a)** Show a possible structure for the species responsible for the peak at m/z = 73. Explain your answer.

Structure

Explanation:

(b) What is the size of the peak at m/z = 73 relative to that of the peak at m/z = 72? Explain your answer.
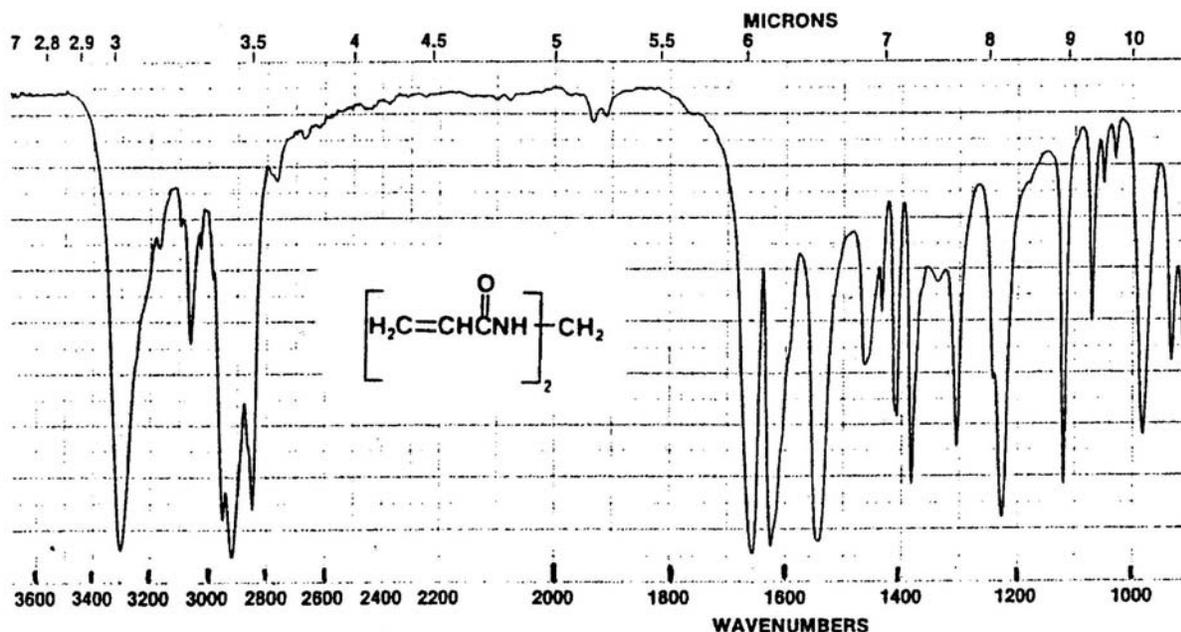
Answer:

Explanation:

(c) Write balanced equations showing how the molecular ion fragments to give afford ions with m/z = 43 and m/z = 29 and show clear structures for these ions.

Structure of ion with m/z = 43
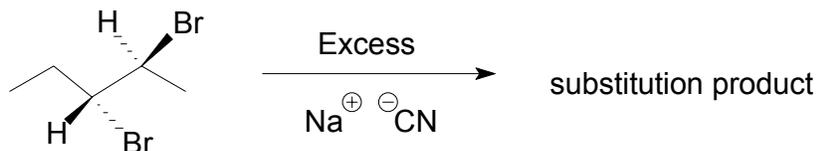
Structure of ion with m/z = 29

11. 15 Points. (a) Consider the infrared spectrum below. Using labeled arrows indicate the position of the peak that correspond to:

(i) C=C stretch   (ii) C-H stretch (on sp^3 C atom)   (iii) N-H stretch   (iv) C=O stretch

(b) What is the correct stereochemistry of the substitution product obtained in the reaction below:

Excess

$\overset{\oplus}{Na}\ \overset{\ominus}{CN}$

substitution product

Answer: (Circle ONE)   4R,3S   2S,3R   2R,3S   2R,3R   4R,3R   4S,3R   2S,3S

(c) What is the shape of the molecule of NH_3? What is the H-N-H bond angle in NH_3?

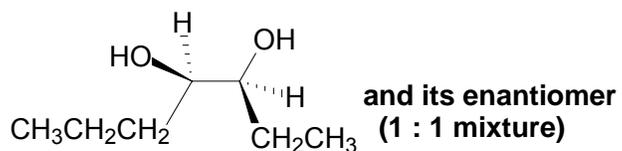| Shape of NH_3 |
|---|

H—N—H bond angle in NH_3 =

12.   11 Points.

Write a step-by step mechanism for the following reaction:
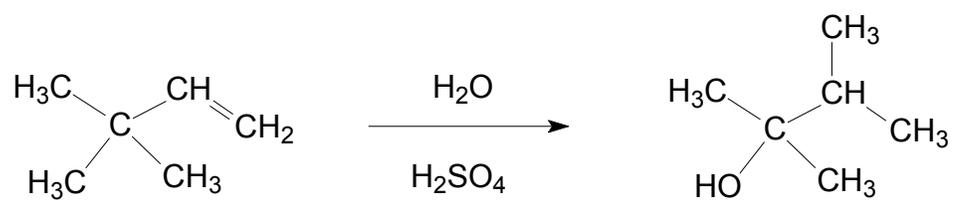
13. 16 Points. Propose a step-by-step synthesis of:
starting from a terminal alkyne with up to 5 C atoms
and any other hydrocarbon.

Show all steps and all reagents needed.
No mechanisms are needed.

HO   H   OH

$CH_3CH_2CH_2$ CH_2CH_3 **and its enantiomer**
H   **(1 : 1 mixture)**

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