Chem 341 Organic Chemistry I

Final Exam - KEY

12 December 2006

NAME_____

Please read through each question carefully and answer in the spaces provided.

A good strategy is to go through the test and answer all the questions you can do easily. Then go back and tackle the more difficult problems.

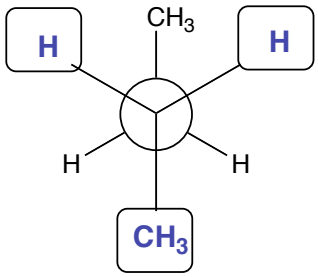
Please make sure your structures are drawn clearly and indicate any necessary stereochemistry with bold or dashed bonds.

Finally, think about what you know. Reason and common sense can often help you out.

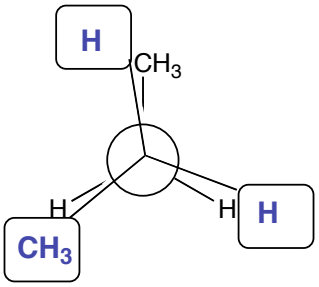
You may use the back of the pages for scratch paper.

Problem 1	12 pts	_____	Problem 9	9 pts	_____
Problem 2	12 pts	_____	Problem 10	9 pts	_____
Problem 3	12 pts	_____	Problem 11	33 pts	_____
Problem 4	12 pts	_____	Problem 12	12 pts	_____
Problem 5	12 pts	_____	Problem 13	12 pts	_____
Problem 6	8 pts	_____	Problem 14	28 pts	_____
Problem 7	21 pts	_____	BONUS	15 pts	_____
Problem 8	8 pts	_____			
			TOTAL	200 pts	_____

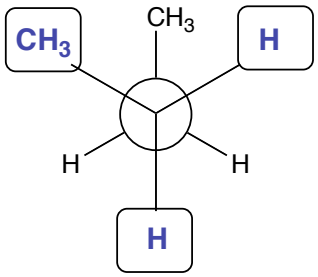
1. Fill in the missing groups on the front carbon in the Newman projections for the conformers of butane. (12 pts)



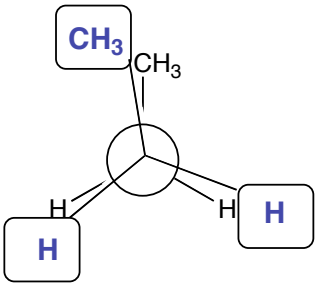
anti-butane



lower energy eclipsed



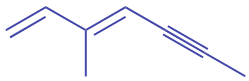
gauche-butane



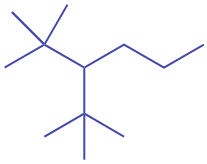
higher energy eclipsed

2. Draw a structure corresponding to each of the following names. (12 pts)

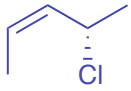
a) *E*-3-methyl-1,3-heptadien-5-yne



b) 3-(1,1-dimethylethyl)-2,2-dimethylhexane



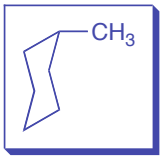
c) *S-cis*-4-chloro-2-pentene



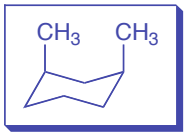
3 For each of the following pairs of conformers, circle the one that would be LEAST stable (higher energy). (12 pts)

a)

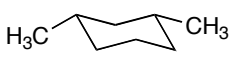
or



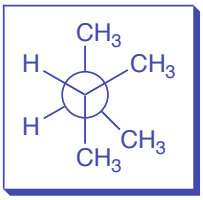
c)



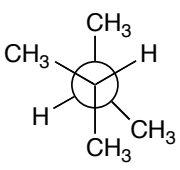
or



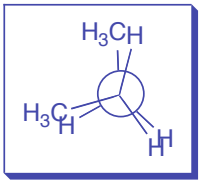
b)



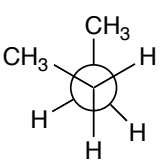
or



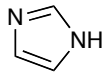
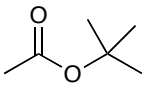
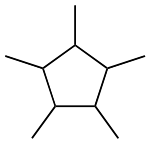
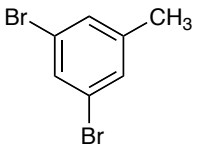
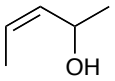
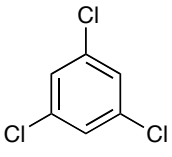
d)



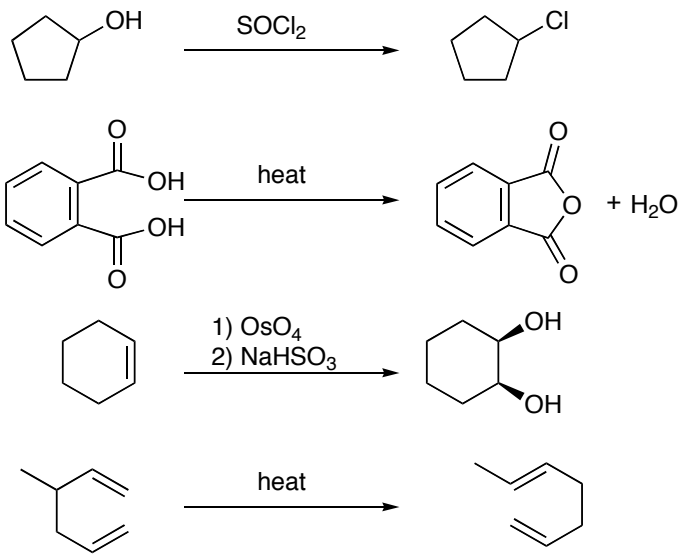
or



4. For each molecule below, indicate how many different resonances you would observe in the proton and carbon NMR. (12 pts)

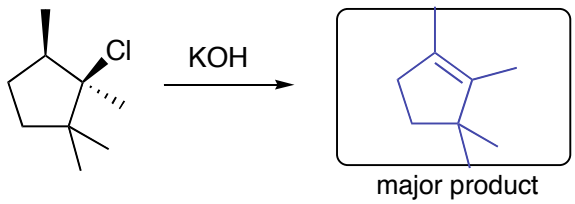
	Number of ^{1}H Resonances	Number of ^{13}C Resonances
	4	3
	2	4
	2	2
	3	5
	6	5
	1	2

5. For each reaction below, place a check box that corresponds to the type of reaction. (12 pts)

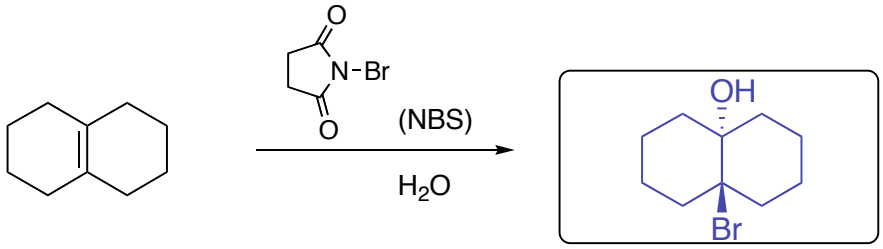


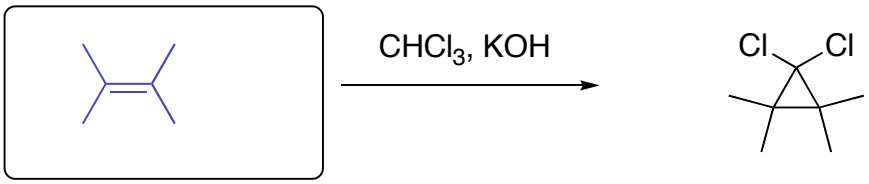
addition	elimination	substitution	rearrangement
		X	
	X		
X			
			X

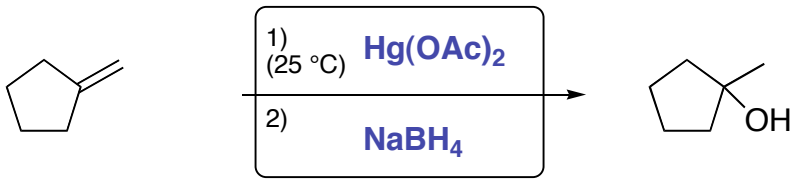
6. The chlorides shown belown can elminate in more than one way. Each isomer provides a different product upon treatment with KOH. Draw the major product for each. (8 pts)

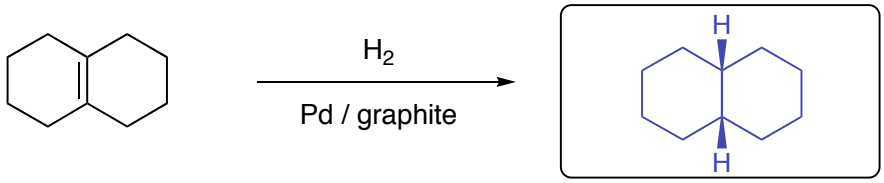


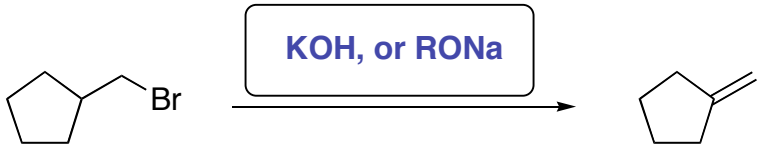
7. Provide the missing major organic product, the starting organic reactant, or the reagents for the following reactions. Be sure to indicate any stereochemistry clearly. (21 points)

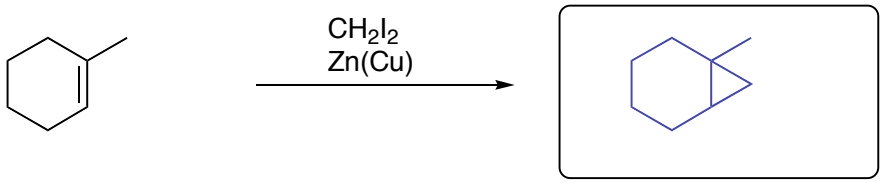
(a) 

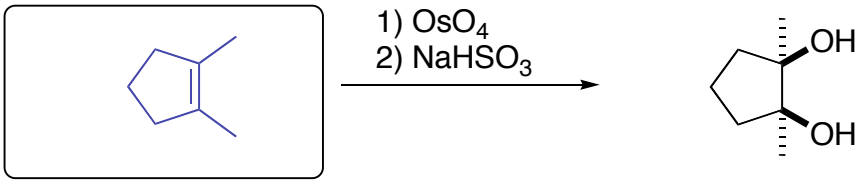
(b) 

(c) 

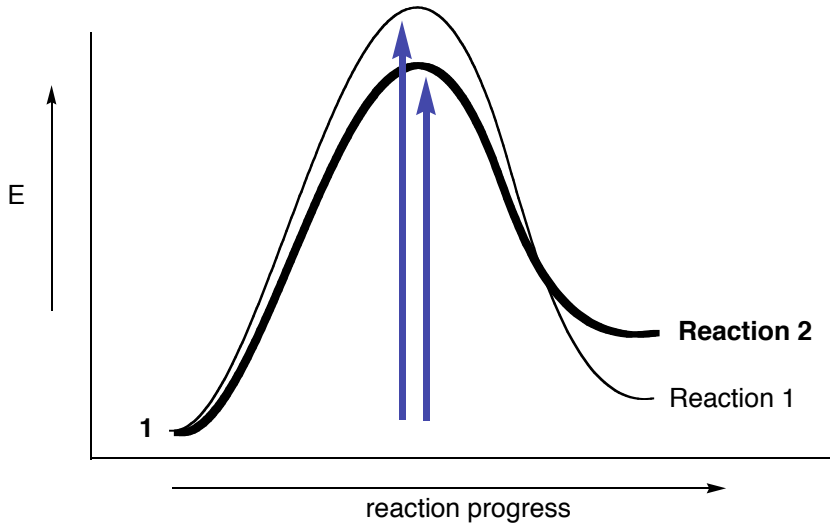
(d) 

(e) 

(f) 

(g) 

8. The following energy diagram illustrates two reaction pathways starting from the same fictitious starting material **1**. On the diagram show the activation energies for each with an arrow. (8 pts)



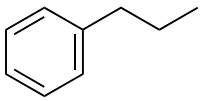
a) Which reaction has the fastest reaction rate (circle one)?

Reaction 1 **Reaction 2**

b) Which reaction produces the most stable product (circle one)?

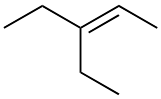
Reaction 1 **Reaction 2**

9. For each molecule below, circle the m/z you would expect to see for a significant fragment peak (perhaps the base peak) in the mass spectrum. (mass of C=12, H=1) (9 pts)

(a) 

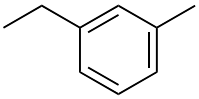
expected fragment m/z

91 105 120

(b) 

expected fragment m/z

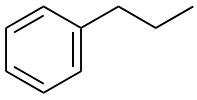
69 **83** 98

(c) 

expected fragment m/z

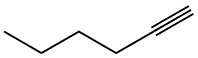
91 **105** 119

10. For each of the molecules below, circle the IR stretching frequency you would expect to observe for that molecule. Do not circle more than one answer in each case. (9 pts)

(a) 

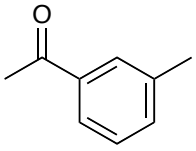
expected IR absorbance

3300 (strong) **3069** 1720 (strong)

(b) 

expected IR absorbance

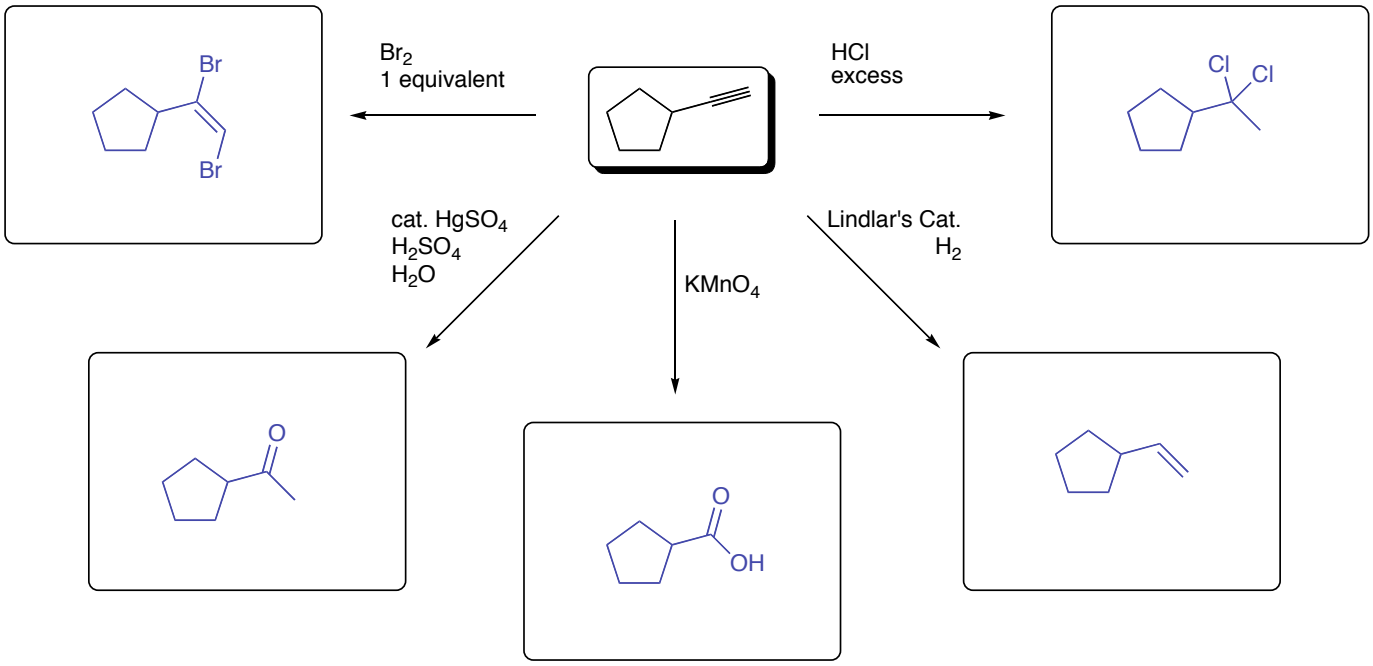
3300 (strong) 3069 1720 (strong)

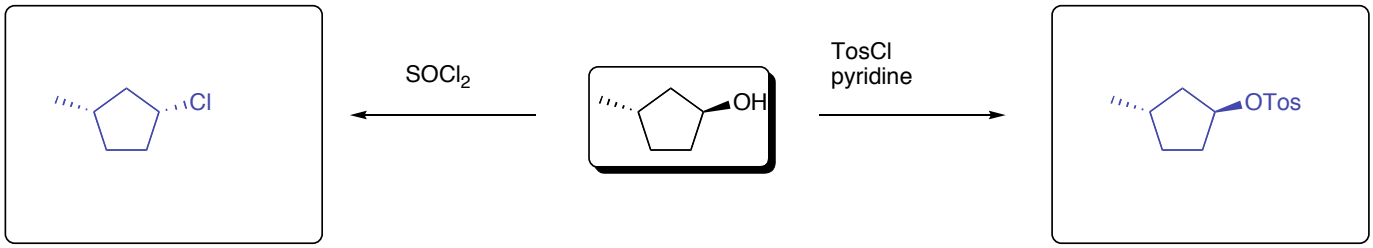
(c) 

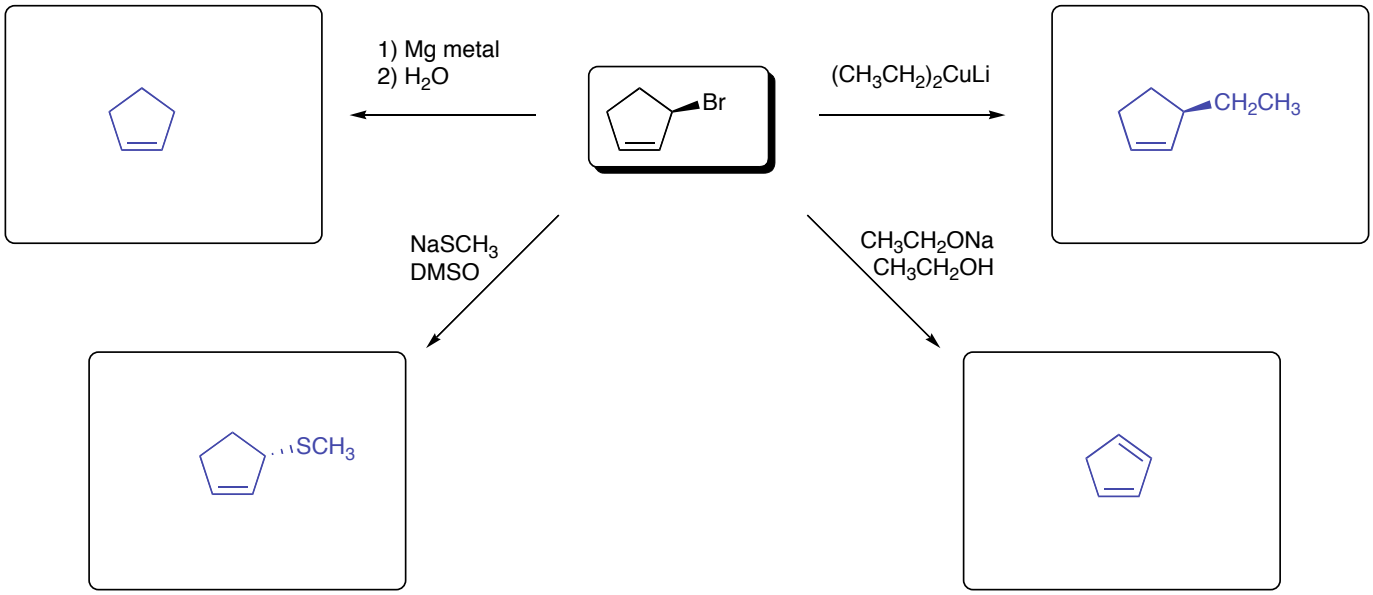
expected IR absorbance

3300 (strong) 2210 **1720 (strong)**

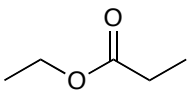
11. Provide the major organic product for the following reactions showing any stereochemistry clearly if necessary. (33 pts)



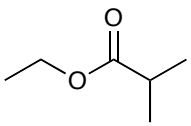




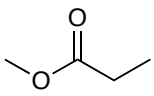
12. Shown below are the ^{1}H NMR spectra for three different compounds. These spectra corresond to three of the five compounds that are drawn for you **A-E**. Match the correct structure to the correct NMR spectra. (12 pts)



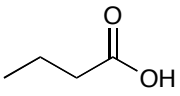
A



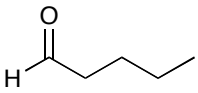
B



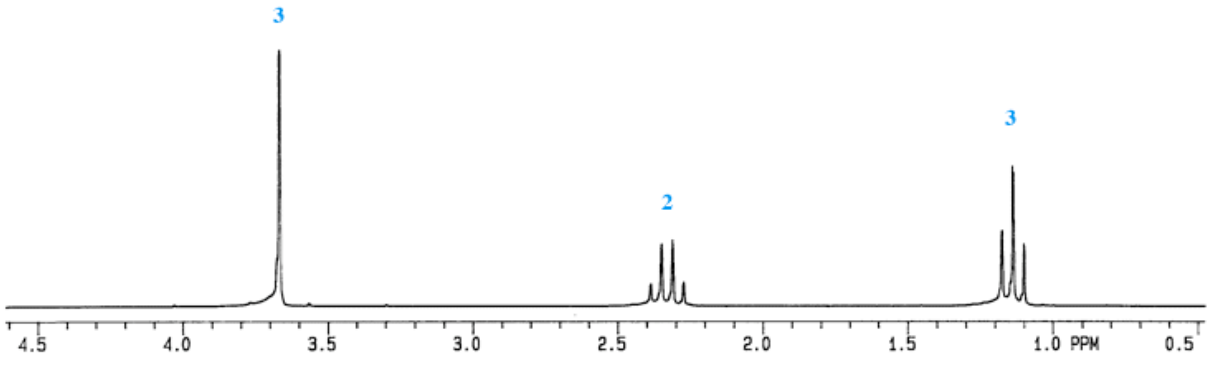
C



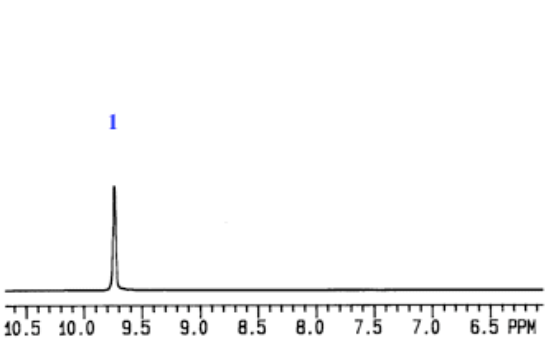
D

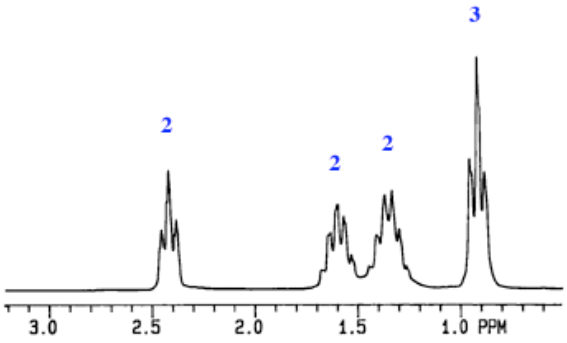


E

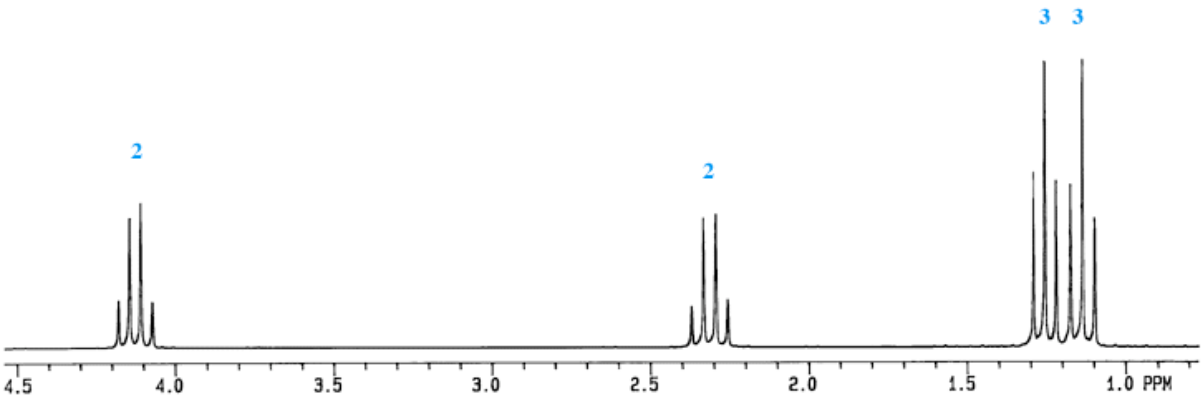


C



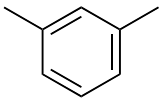


E

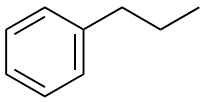


A

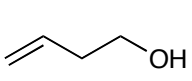
13. Shown below are the ^{13}C NMR spectra for three different compounds. These spectra corresond to three of the five compounds that are drawn for you **A-E**. Match the correct structure to the correct NMR spectra. (12 pts)



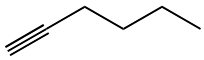
A



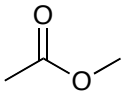
B



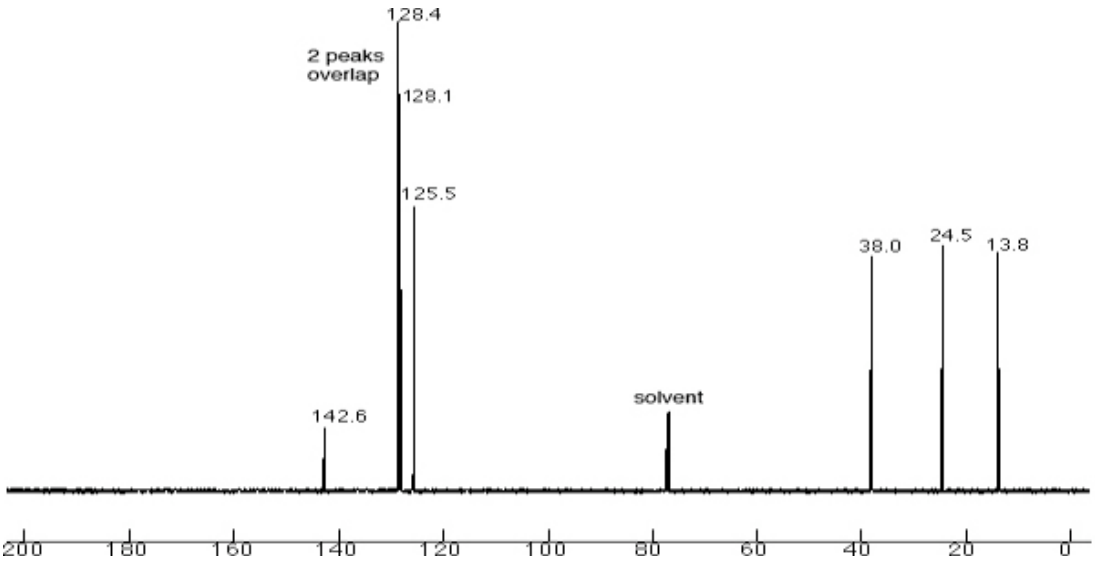
C



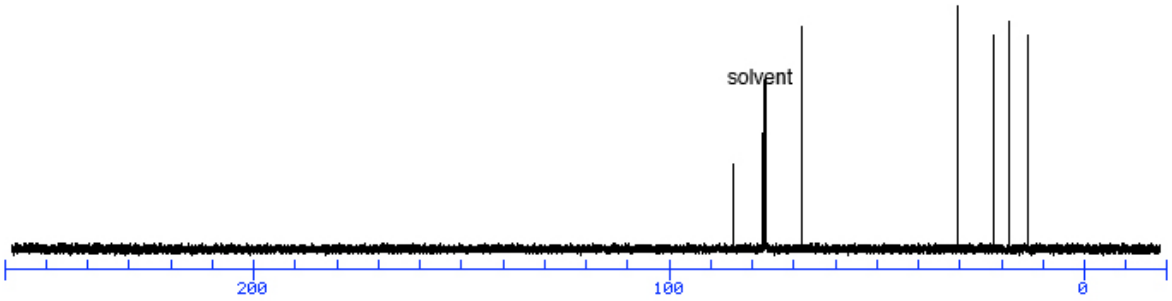
D



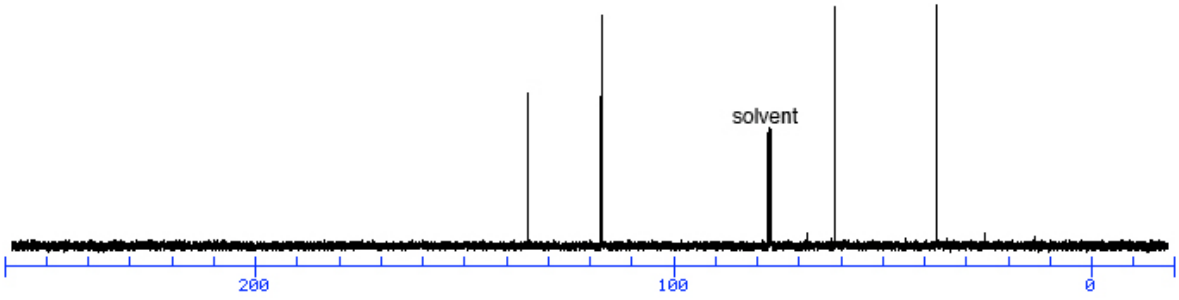
E



B



D



C

14. The proton NMR and IR spectra for an unknown compound with the molecular formula $C_4H_{10}O$ are shown below. Answer the following questions about this spectra. (28 pts)

a) How many units of unsaturation does the molecule have? **0**

b) What kind of functional group is present? **alcohol**

c) Which IR peak is indicative of the functional group? (circle one)

3339 cm^{-1} 2597 cm^{-1} 1471 cm^{-1} 1041 cm^{-1}

d) Which of the proton resonances belongs to methyl groups? (circle one)

3.90 ppm 3.40 ppm 1.75 ppm **0.90 ppm**

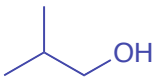
e) Which of the proton resonances would you expect to disappear if the sample were shaken with D_2O? (circle one)

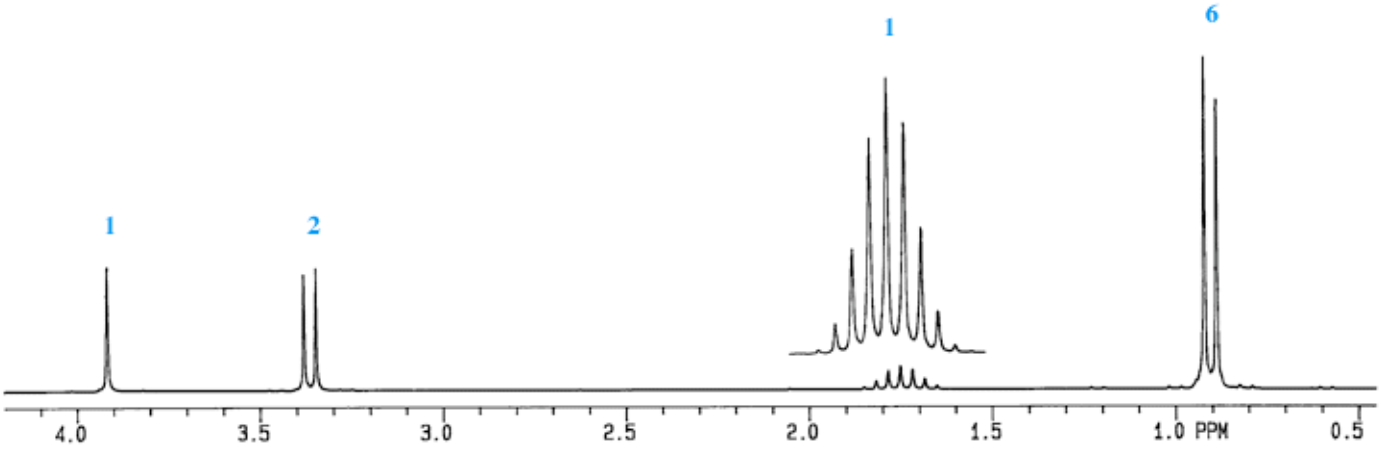
3.90 ppm 3.40 ppm 1.75 ppm 0.90 ppm

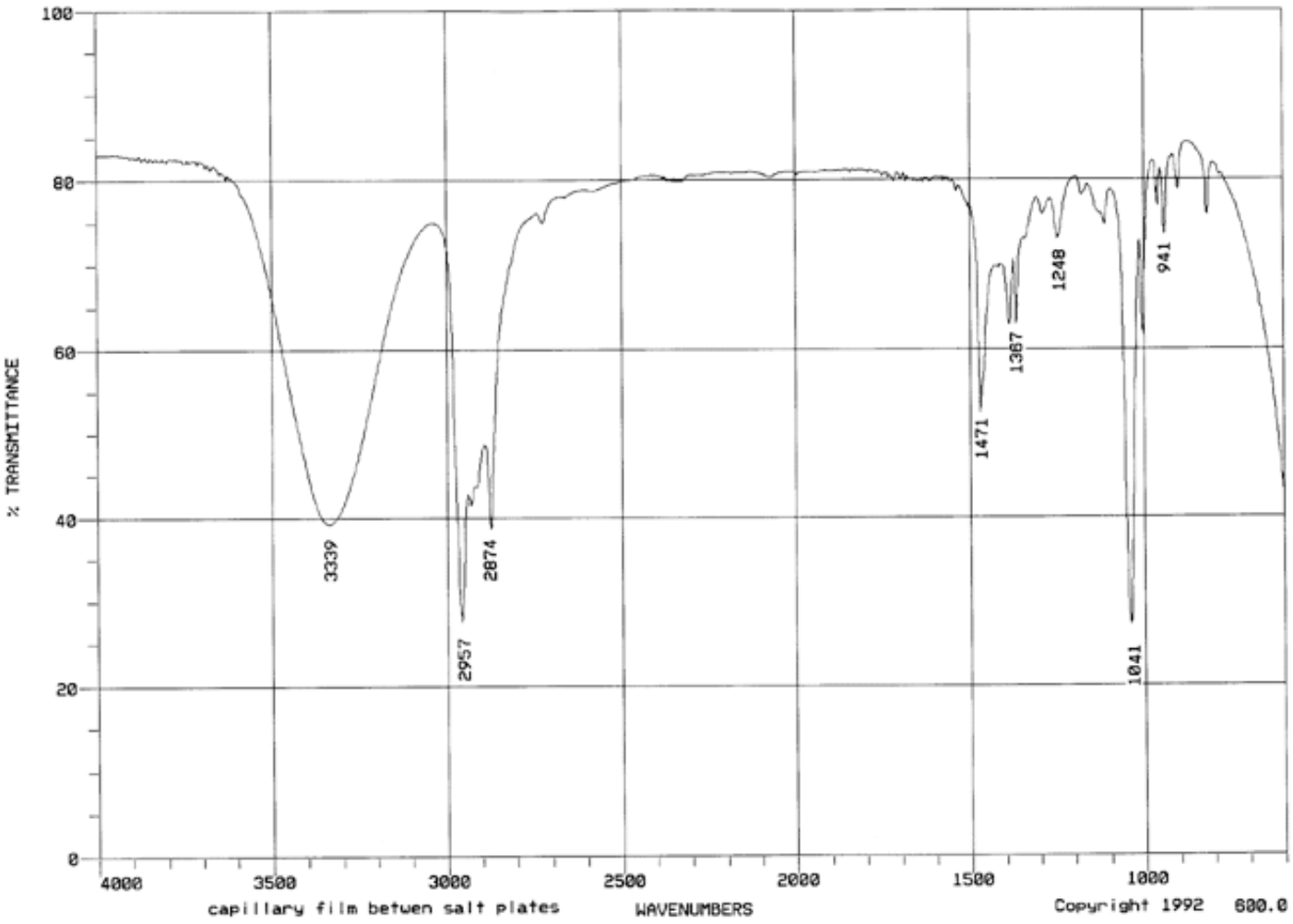
f) What is the multiplicity (how many peaks is it split into) of the resonance at 1.75 ppm?

doublet quartet septet octet **nonet**

g) What is the structure of this molecule?





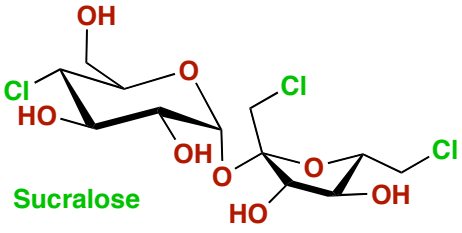


BONUS PROBLEMS (5 points each) ☺

1. On the first day of class this year I discussed the reaction shown in the stamp on the front page of this exam. Briefly describe the significance of Wöhler's work.

This was the synthesis of Urea - the first time an "organic" molecule was synthesized from purely inorganic starting materials. No vital force of life.

2. Draw the structure for Sucralose (aka - Splenda).

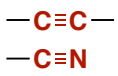


Sucralose

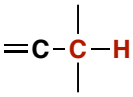
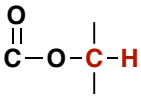
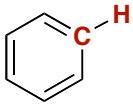
3) Androstenedione belongs to what class of compounds? What is it's biological role?

Steroids, male sex hormones

Infrared Stretching Absorptions

Functional Group	Wavenumber Range (cm^{-1})	Absorption Strength	notes
	2850-2960	medium-strong	below 3000
	3020-3100	medium	above 3000
	3300	strong	above 3000
	3400-3650	broad-strong	
	2100-2260	medium	
	1680-1750	strong	

Typical NMR Chemical Shifts

Functional Group	Type	^{1}H Chemical Shift (ppm)	^{13}C Chemical Shift (ppm)
	Alkane	0.7 -1.8	10 - 60
	Allylic or next to carbonyl	1.6 - 2.4	30 - 60
	next to halogen or alcohol	2.5 - 4.0	20 - 85
	next to oxygen of an ester	4.0 - 5.0	50 - 85
	vinylic	4.5 - 6.5	110 - 150
	acetylenic	2.0-2.5	65 - 90
	aromatic	6.5 - 8.0	110 - 140
	aldehyde	9.7 - 10.0	190 - 220
	alcohol	varies widely will exchange with D_2O	N/A
	carbonyl of ester, amide, or carboxylic acid (X = O, N)	N/A	165 - 185
	carbonyl of ketone or aldehyde	N/A	190 - 220

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)