

NAME (Print): \_\_\_\_\_

Chemistry 320M/328M  
Dr. Brent Iverson  
2nd Midterm  
October 24, 2019

SIGNATURE: \_\_\_\_\_

EID: \_\_\_\_\_

Please print the  
first three letters  
of your last name  
in the three boxes

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**Please Note:** This test may be a bit long, but there is a reason. I would like to give you a lot of little questions, so you can find ones you can answer and show me what you know, rather than just a few questions that may be testing the one thing you forgot. **I recommend you look the exam over and answer the questions you are sure of first**, then go back and try to figure out the rest. Also make sure to **look at the point totals** on the questions as a guide to help budget your time.

**You cannot use a red pen to take the exam. You must have your answers written in PERMANENT ink if you want a regrade!!!! This means no test written in pencil or ERASABLE INK will be regraded.**

**Please note: We routinely xerox a number of exams following initial grading to guard against receiving altered answers during the regrading process.**

**FINALLY, DUE TO SOME UNFORTUNATE RECENT INCIDENTS YOU ARE NOT ALLOWED TO INTERACT WITH YOUR CELL PHONE IN ANY WAY. IF YOU TOUCH YOUR CELL PHONE DURING THE EXAM YOU WILL GET A "0" NO MATTER WHAT YOU ARE DOING WITH THE PHONE. PUT IT AWAY AND LEAVE IT THERE!!!**

Page	Points
<b>1</b>	<b>(20)</b>
<b>2</b>	<b>(27)</b>
<b>3</b>	<b>(24)</b>
<b>4</b>	<b>(22)</b>
<b>5</b>	<b>(24)</b>
<b>6</b>	<b>(20)</b>
<b>7</b>	<b>(25)</b>
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<b>10</b>	<b>(23)</b>
<b>11</b>	<b>(25)</b>
<b>12</b>	<b>(18)</b>
<b>13</b>	<b>(15)</b>
<b>14</b>	<b>(15)</b>
<b>15</b>	<b>(16)</b>
<b>16</b>	<b>(23)</b>
<b>Total</b>	<b>(321)</b>

# Student Honor Code

"As a student of The University of Texas at Austin, I shall abide by the core values of the University and uphold academic integrity."

(Your signature)

# PERIODIC TABLE OF THE ELEMENTS

### Elementary Subatomic Particles

Symbol	Electron	Proton	Neutron	Photon	Neutrino
Rest mass (kg)	$9.10938291 \times 10^{-31}$	$1.6726219 \times 10^{-27}$	$1.6749273 \times 10^{-27}$	0	0
Relative charge (e)	-1	+1	0	0	0
Spin quantum number	1/2	1/2	1/2	1	1/2

**Key:**  $e^-$  = electron,  $p^+$  = proton,  $n^0$  = neutron,  $\gamma$  = photon,  $\nu$  = neutrino.

### % Ionic Character of a Single Chemical Bond

**Key:**  $\chi$  = electronegativity,  $\Delta\chi$  = difference in electronegativity.

1 IA		2 IIA										3 IIIA										4 IVA										5 VA										6 VIA										7 VIIA										8 VIIIA										9 VIIIA										10 VIIIA										11 IB										12 IIB										13 IIIB										14 IVB										15 VB										16 VIB										17 VIIB										18 VIII																																																																																																																																																																																																																																																																																																																																																		
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1.00794	4.002602	6.941	9.012182	10.811	12.011	14.0074	15.9994	16.9994	18.9994	20.1797	20.1797	22.989769	24.30409	26.981538	28.0855	30.973762	32.06	34.96288	36.966664	39.0983	40.078	42.959724	44.955942	47.882794	49.951969	51.9404	54.938045	56.93394	58.9332	60.931025	62.929671	64.927419	66.925154	68.922876	70.920675	72.91845	74.91621	76.91395	78.91168	80.90938	82.90704	84.90468	86.90231	88.90988	90.90753	92.90508	94.90262	96.90015	98.90768	100.9052	102.90273	104.90023	106.90772	108.9052	110.9027	112.90019	114.90768	116.90516	118.90264	120.90012	122.90759	124.90507	126.90255	128.90003	130.90751	132.90499	134.90247	136.90995	138.90743	140.90491	142.90239	144.90987	146.90735	148.90483	150.90231	152.90979	154.90727	156.90475	158.90223	160.90971	162.90719	164.90467	166.90215	168.90963	170.90711	172.90459	174.90207	176.90955	178.90703	180.90451	182.90199	184.90947	186.90695	188.90443	190.90191	192.90939	194.90687	196.90435	198.90183	200.90931	202.90679	204.90427	206.90175	208.90923	210.90671	212.90419	214.90167	216.90915	218.90663	220.90411	222.90159	224.90907	226.90655	228.90403	230.90151	232.90899	234.90647	236.90395	238.90143	240.90891	242.90639	244.90387	246.90135	248.90883	250.90631	252.90379	254.90127	256.90875	258.90623	260.90371	262.90119	264.90867	266.90615	268.90363	270.90111	272.90859	274.90607	276.90355	278.90103	280.90851	282.90599	284.90347	286.90095	288.90843	290.90591	292.90339	294.90087	296.90835	298.90583	300.90331	302.90079	304.90827	306.90575	308.90323	310.90071	312.90819	314.90567	316.90315	318.90063	320.90811	322.90559	324.90307	326.90055	328.90803	330.90551	332.90299	334.90047	336.90795	338.90543	340.90291	342.90039	344.90787	346.90535	348.90283	350.90031	352.90779	354.90527	356.90275	358.90023	360.90771	362.90519	364.90267	366.90015	368.90763	370.90511	372.90259	374.90007	376.90755	378.90503	380.90251	382.90000	384.90748	386.90496	388.90244	390.90000	392.90748	394.90496	396.90244	398.90000	400.90748	402.90496	404.90244	406.90000	408.90748	410.90496	412.90244	414.90000	416.90748	418.90496	420.90244	422.90000	424.90748	426.90496	428.90244	430.90000	432.90748	434.90496	436.90244	438.90000	440.90748	442.90496	444.90244	446.90000	448.90748	450.90496	452.90244	454.90000	456.90748	458.90496	460.90244	462.90000	464.90748	466.90496	468.90244	470.90000	472.90748	474.90496	476.90244	478.90000	480.90748	482.90496	484.90244	486.90000	488.90748	490.90496	492.90244	494.90000	496.90748	498.90496	500.90244	502.90000	504.90748	506.90496	508.90244	510.90000	512.90748	514.90496	516.90244	518.90000	520.90748	522.90496	524.90244	526.90000	528.90748	530.90496	532.90244	534.90000	536.90748	538.90496	540.90244	542.90000	544.90748	546.90496	548.90244	550.90000	552.90748	554.90496	556.90244	558.90000	560.90748	562.90496	564.90244	566.90000	568.90748	570.90496	572.90244	574.90000	576.90748	578.90496	580.90244	582.90000	584.90748	586.90496	588.90244	590.90000	592.90748	594.90496	596.90244	598.90000	600.90748	602.90496	604.90244	606.90000	608.90748	610.90496	612.90244	614.90000	616.90748	618.90496	620.90244	622.90000	624.90748	626.90496	628.90244	630.90000	632.90748	634.90496	636.90244	638.90000	640.90748	642.90496	644.90244	646.90000	648.90748	650.90496	652.90244	654.90000	656.90748	658.90496	660.90244	662.90000	664.90748	666.90496	668.90244	670.90000	672.90748	674.90496	676.90244	678.90000	680.90748	682.90496	684.90244	686.90000	688.90748	690.90496	692.90244	694.90000	696.90748	698.90496	700.90244	702.90000	704.90748	706.90496	708.90244	710.90000	712.90748	714.90496	716.90244	718.90000	720.90748	722.90496	724.90244	726.90000	728.90748	730.90496	732.90244	734.90000	736.90748	738.90496	740.90244	742.90000	744.90748	746.90496	748.90244	750.90000	752.90748	754.90496	756.90244	758.90000	760.90748	762.90496	764.90244	766.90000	768.90748	770.90496	772.90244	774.90000	776.90748	778.90496	780.90244	782.90000	784.90748	786.90496	788.90244	790.90000	792.90748	794.90496	796.90244	798.90000	800.90748	802.90496	804.90244	806.90000	808.90748	810.90496	812.90244	814.90000	816.90748	818.90496	820.90244	822.90000	824.90748	826.90496	828.90244	830.90000	832.90748	834.90496	836.90244	838.90000	840.90748	842.90496	844.90244	846.90000	848.90748	850.90496	852.90244	854.90000	856.90748	858.90496	860.90244	862.90000	864.90748	866.90496	868.90244	870.90000	872.90748	874.90496	876.90244	878.90000	880.90748	882.90496	884.90244	886.90000	888.90748	890.90496	892.90244	894.90000	896.90748	898.90496	900.90244	902.90000	904.90748	906.90496	908.90244	910.90000	912.90748	914.90496	916.90244	918.90000	920.90748	922.90496	924.90244	926.90000	928.90748	930.90496	932.90244	934.90000	936.90748	938.90496	940.90244	942.90000	944.90748	946.90496	948.90244	950.90000	952.90748	954.90496	956.90244	958.90000	960.90748	962.90496	964.90244	966.90000	968.90748	970.90496	972.90244	974.90000	976.90748	978.90496	980.90244	982.90000	984.90748	986.90496	988.90244	990.90000	992.90748	994.90496	996.90244	998.90000	1000.90748

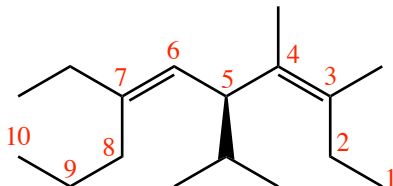
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Compound		pK <sub>a</sub>
Hydrochloric acid	$\underline{\text{H}}\text{-Cl}$	-7
Protonated alcohol	$\text{RCH}_2\text{O}\underline{\text{H}}_2^{\oplus}$	-2
Hydronium ion	$\underline{\text{H}}_3\text{O}^{\oplus}$	-1.7
Carboxylic acids	$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\underline{\text{O}}-\underline{\text{H}}$	3-5
Thiols	$\text{RCH}_2\text{S}\underline{\text{H}}$	8-9
Ammonium ion	$\underline{\text{H}}_4\text{N}^{\oplus}$	9.2
β-Dicarbonyls	$\text{RC}-\overset{\text{O}}{\parallel}{\text{C}}-\underline{\text{C}}\text{H}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{CR}'$	10
Primary ammonium	$\underline{\text{H}}_3\text{N}^{\oplus}\text{CH}_2\text{CH}_3$	10.5
β-Ketoesters	$\text{RC}-\overset{\text{O}}{\parallel}{\text{C}}-\underline{\text{C}}\text{H}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OR}'$	11
β-Diesters	$\text{ROC}-\overset{\text{O}}{\parallel}{\text{C}}-\underline{\text{C}}\text{H}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OR}'$	13
Water	$\text{HO}\underline{\text{H}}$	15.7
Alcohols	$\text{RCH}_2\text{O}\underline{\text{H}}$	15-19
Acid chlorides	$\text{RC}\underline{\text{H}}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{Cl}$	16
Aldehydes	$\text{RC}\underline{\text{H}}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	18-20
Ketones	$\text{RC}\underline{\text{H}}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}'$	18-20
Esters	$\text{RC}\underline{\text{H}}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OR}'$	23-25
Terminal alkynes	$\text{RC}\equiv\text{C}-\underline{\text{H}}$	25
LDA	$\underline{\text{H}}-\text{N}(\text{i-C}_3\text{H}_7)_2$	40
Terminal alkenes	$\text{R}_2\text{C}=\underset{\text{H}}{\text{C}}-\underline{\text{H}}$	44
Alkanes	$\text{CH}_3\text{CH}_2-\underline{\text{H}}$	51

1. (2 pts) What is the most important question in organic chemistry?

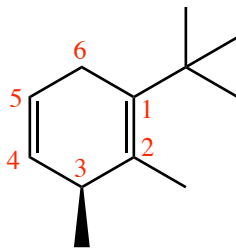
**Where are the electrons?**

2. (12 pts) Write an acceptable IUPAC name for the following two molecules. Where appropriate, use E and Z or R and S.



**(5S,3Z,6Z)-7-ethyl-5-isopropyl-3,4-dimethyl-3,6-decadiene**  
**or**  
**(5S,3Z,6Z)-7-ethyl-3,4-dimethyl-5-(1-methylethyl)-3,6-decadiene**

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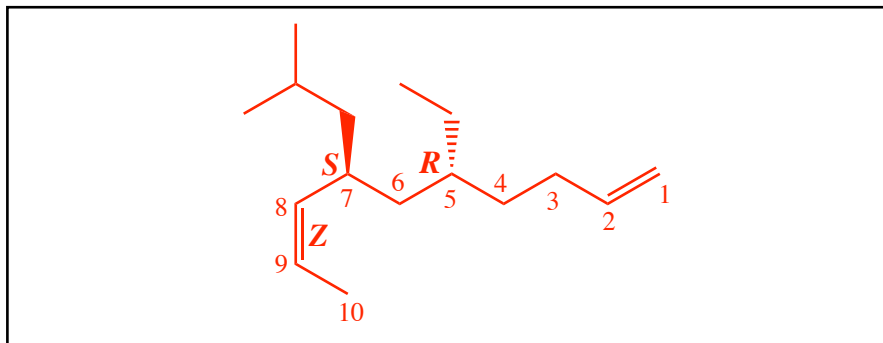


**(3S)-1-tert-butyl-2,3-dimethyl-1,4-cyclohexadiene**  
**or**  
**(3S)-2,3-dimethyl-1-(1,1-dimethylethyl)-1,4-cyclohexadiene**

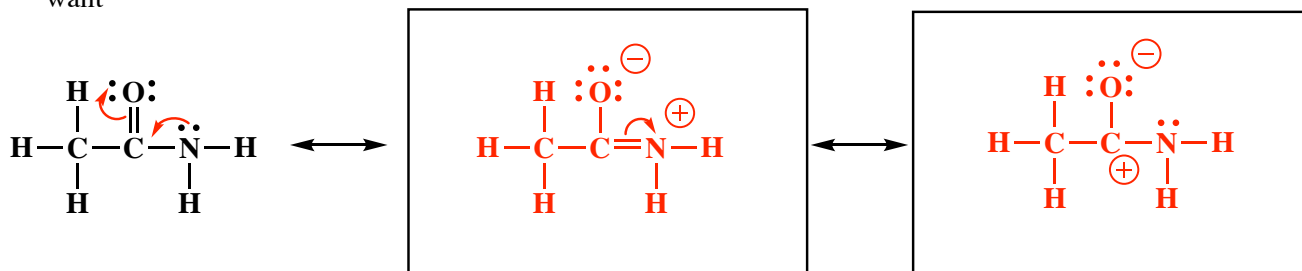
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3. (6 pts) Draw the structure that corresponds to the following name:

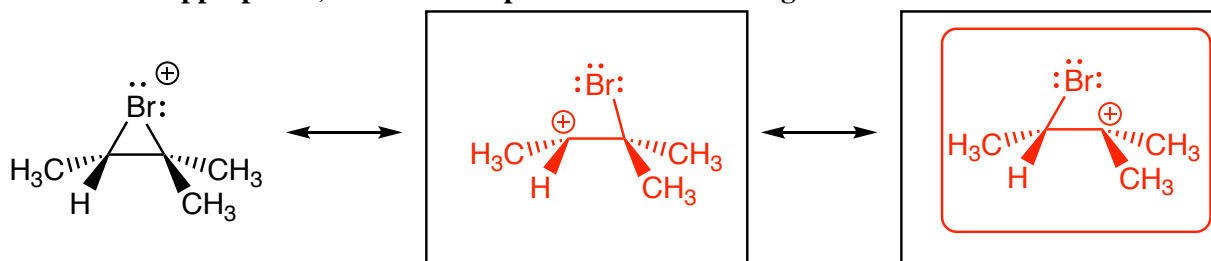
**(5R,7S,Z)-5-ethyl-7-isobutyl-1,8-decadiene**



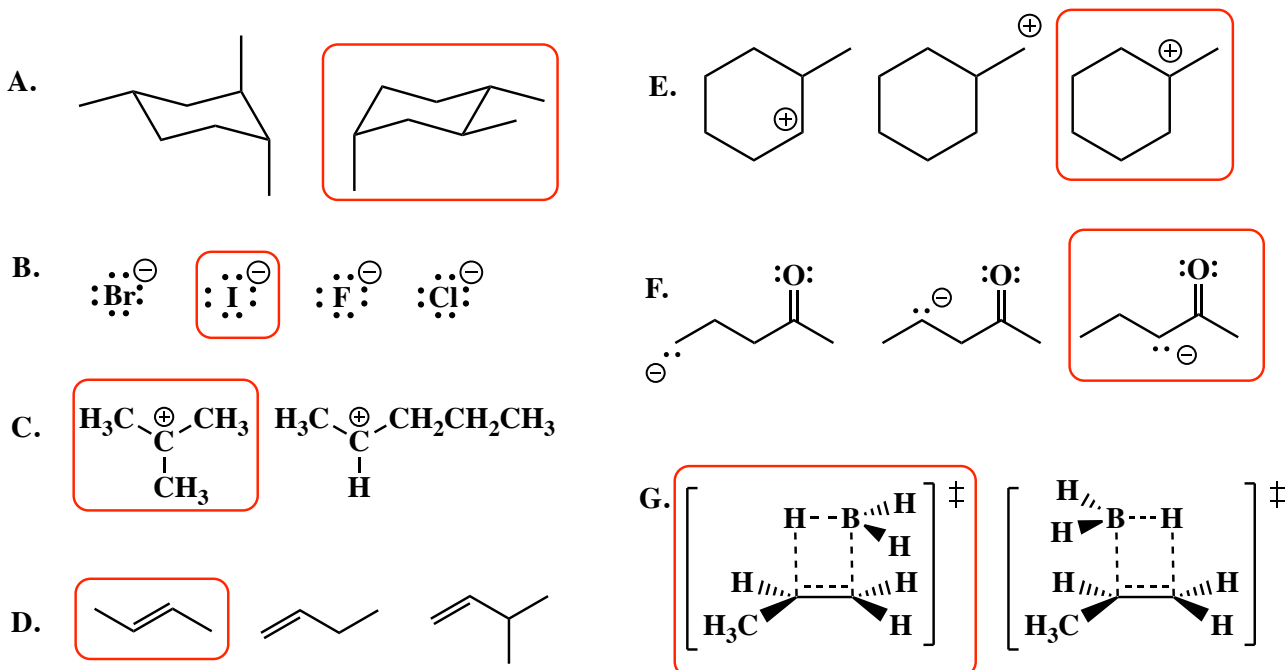
4. (6 pts) Amides are best represented as the hybrid of three contributing structures. Draw the second and third important contributing structures in the spaces provided, including all lone pairs and formal charges. For the two structures on the left in each problem, use arrows to indicate the movement of electrons to give the structures you drew. There is no need to draw any circles around any of these contributing structures. You might want to read these directions again to make sure you know what we want



5. (7 pts) Draw the two other most important contributing structures for the bromonium ion. Draw a circle around the contributing structure you drew that makes the largest contribution to the overall resonance hybrid. You do NOT need to draw arrows on any of the structures for this problem. **Because this is a mechanism type question, use wedges and dashes to indicate stereochemistry, write "racemic" if appropriate, draw all lone pairs and formal charges.**



6. (14 pts) For each set of molecules or ions drawn below, circle the one that is the MOST stable.



7. (24 pts) For each pair of molecules, one is more stable (lower in energy) because of one or more principles we have discussed. **Circle the more stable molecule. Then, in the space provided, write the letter corresponding to the principle or principles (yes there can be more than one!) that explain why the molecule you circled is more stable. Note the wording this year is slightly different than last year.**

A. Steric Strain

B. Angle Strain

C. Torsional Strain

D. The inductive effect

E. Hyperconjugation

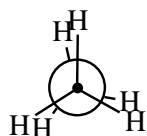
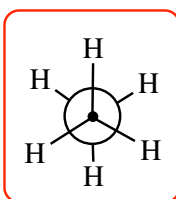
F. Delocalization of a charge over more atoms

G. Delocalization of pi electron density over more than two atoms ("pi-way")

H. Greater s-character of the orbital containing an electron pair on a negatively-charged atom

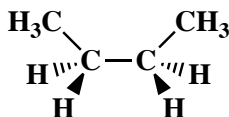
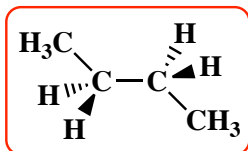
I. The negative charge is on a more electronegative element

J. The negative charge is on a larger atom

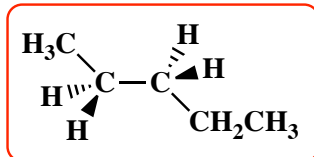
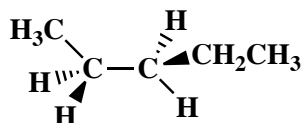


The molecule your circled is more stable upon considering:

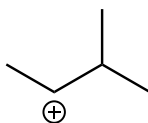
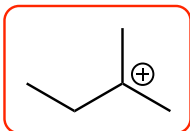
C



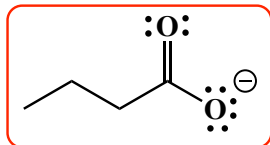
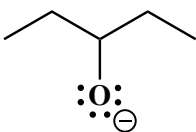
A, C



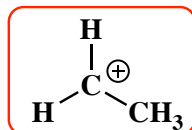
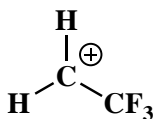
A



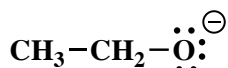
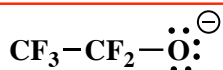
D, E



F, G

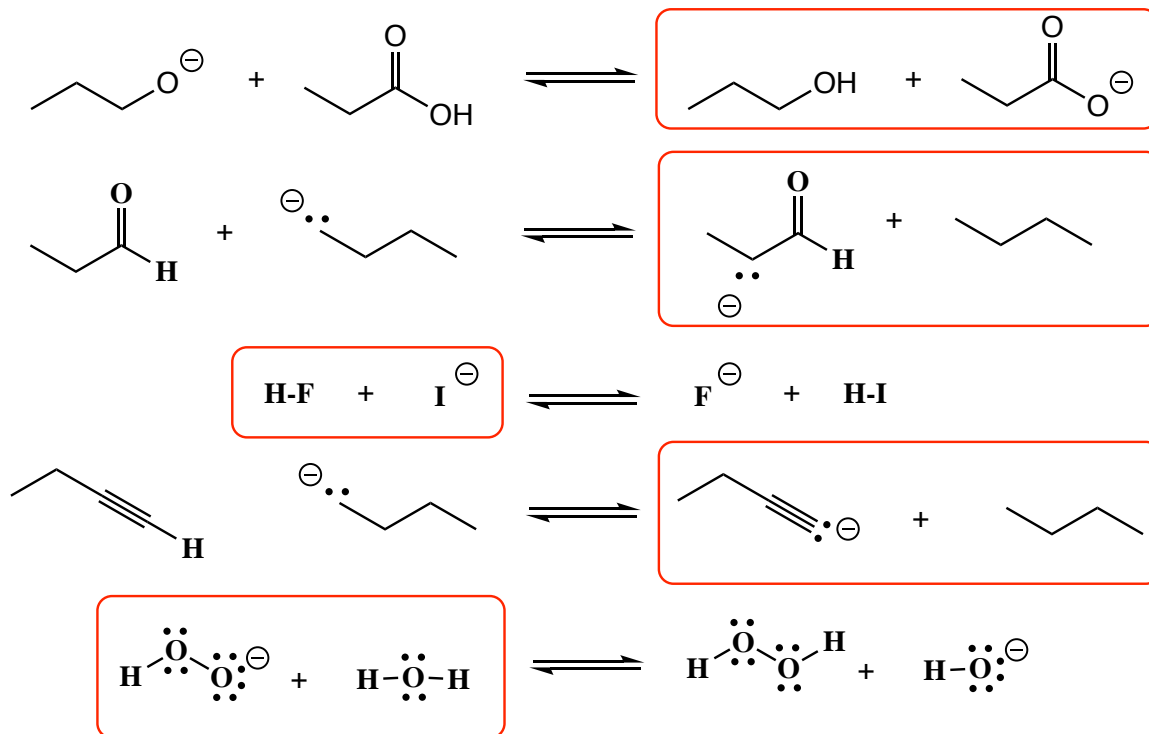


D



D

8. (10 pts) For each acid-base reaction, circle the side of the equation that predominates at equilibrium. In the first four, identify the stronger and weaker acids by comparing relative stabilities of the anions which are the conjugate bases of the two acids. Equilibrium favors formation of the weaker acid. You will notice this means you circled the side with the more stable anion.



9. (2 pts each) List the four mechanistic elements that make up most of the steps of the reactions we will present in the first two semesters of Organic Chemistry:

1. **Make a bond between a nucleophile and an electrophile.**

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2. **Break a bond to give stable molecules or ions.**

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3. **Add a proton**

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4. **Take a proton away**

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10. (2 pts each) List the two most common electron sources for mechanism arrows that we have seen so far this semester:

**Pi bonds and lone pairs on atoms.**

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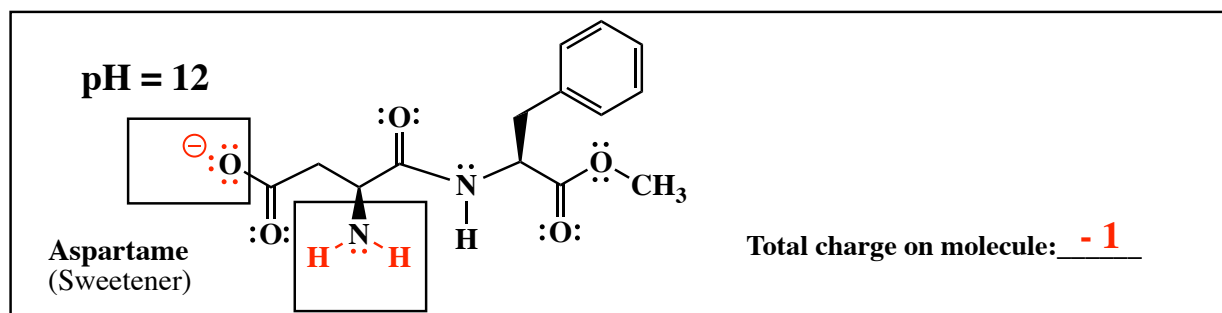
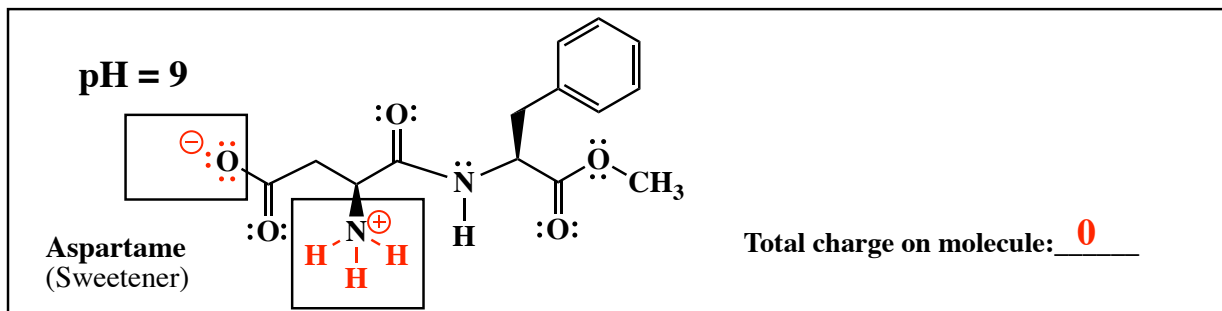
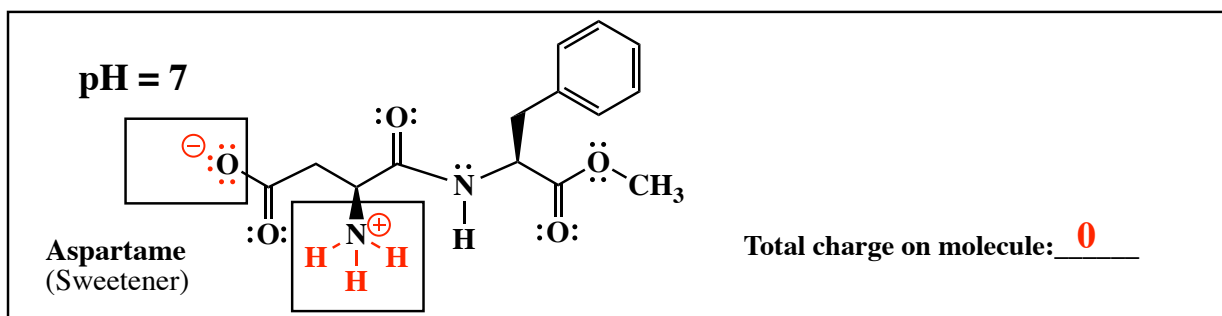
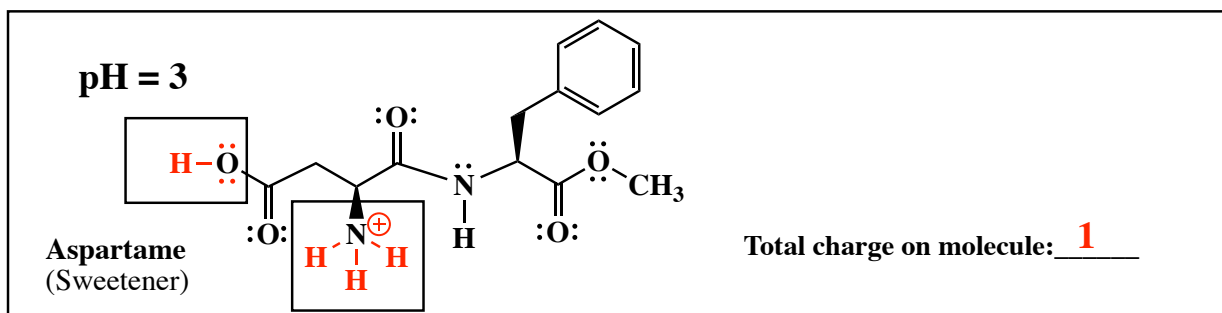
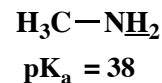
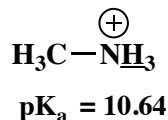
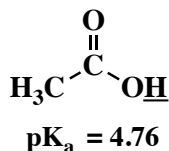
11. (2 pts each) Below are a series of definitions. From the list at the bottom of the page, write the letter, i.e. (A), (C), etc., of the word that corresponds to the following definitions (note you will not use all the letters from down below, there are more words than definitions) I filled in the first one for you.

**Letter of  
the word  
best fitting  
the definition**

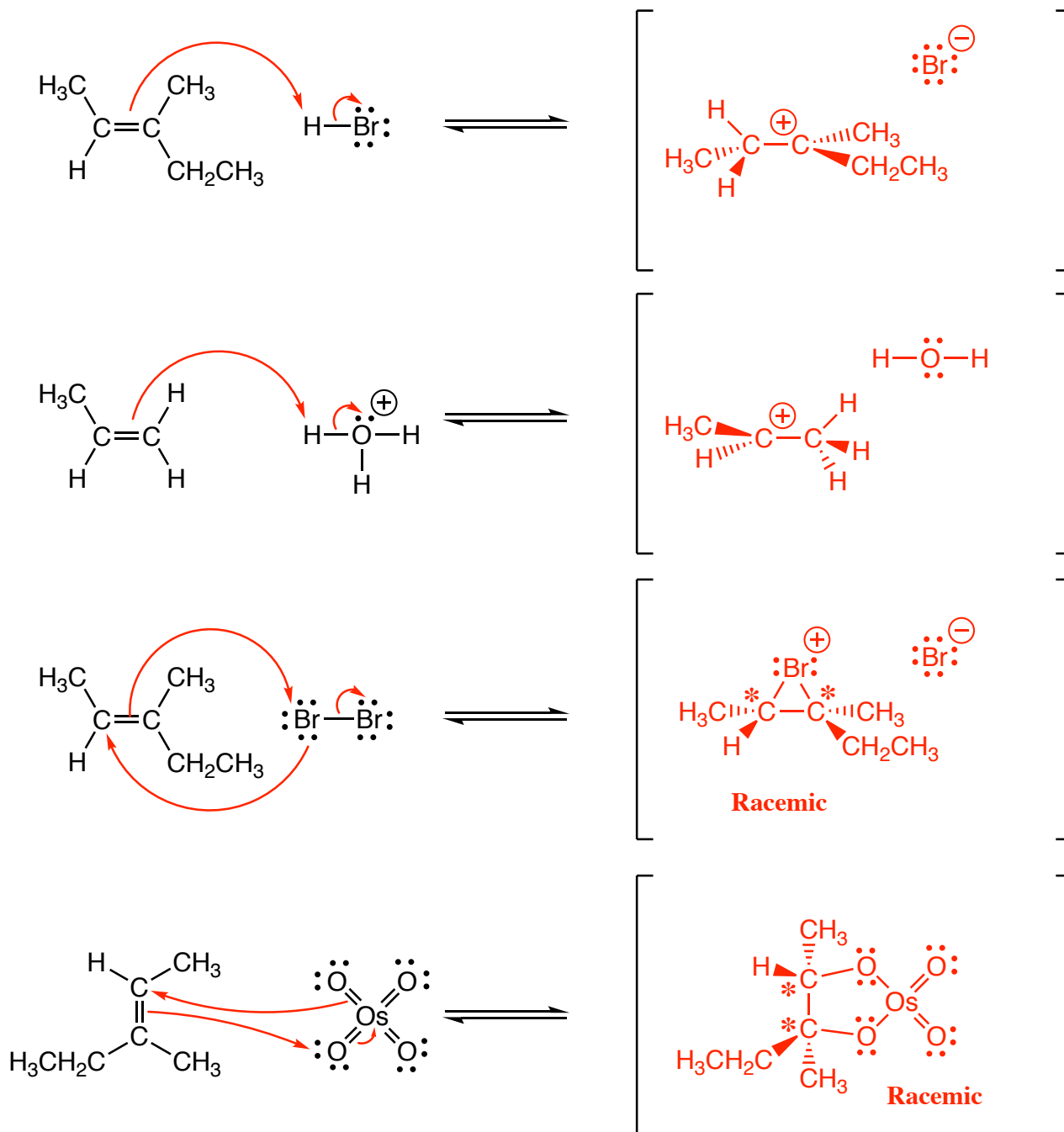
- T Is a great way to stay healthy and deal with the stress of midterms.
- R Complex natural molecules that are built from 5 carbon "isoprene" units in Nature,
- K Contains an electron rich source for a bond forming process. Analogous to a Lewis base
- E Contains an electron deficient atom that serves as the electron sink in a bond forming process (Analogous to a Lewis acid) or possesses a weak bond that breaks to make a stable ion or fragment.
- G Adjacent sigma bonds from attached alkyl groups overlap and share electron density with empty 2p orbital.
- N The analysis of which of the possible constitutional isomes (also called regioisomers) are made in a reaction.
- B Means that the atoms add to either side of a C=C double bond during a chemical reaction.
- Q Means that the atoms add to the same side of a C=C double bond during a chemical reaction.
- L Involves a net loss of electrons and replaces C-H bonds with C-O bonds or pi bonds.
- M Involves a net gain of electrons and replaces C-O or pi bonds with C-H bonds.
- F A molecule that cannot be superimposed on its mirror image (it does not have a plane or center of symmetry).
- D Molecules that are stereoisomers but not enantiomers; a situation that arises when there is more than one chiral center in the same molecule.
- J A molecule with two or more chiral centers yet is not chiral because it contains a symmetry element, usually a plane of symmetry.

<b>Addition reaction</b> (A)	<b>Anti</b> (B)	<b>Cis</b> (C)	<b>Diastereomers</b> (D)	<b>Electrophile</b> (E)	<b>Enantiomer</b> (F)
<b>Hyperconjugation</b> (G)	<b>Inductive effect</b> (H)		<b>Lipid</b> (I)	<b>Meso compound</b> (J)	<b>Nucleophile</b> (K)
<b>Oxidation reaction</b> (L)	<b>Reduction reaction</b> (M)		<b>Regiochemistry</b> (N)	<b>Stereochemistry</b> (O)	<b>Steroid</b> (P)
	<b>Syn</b> (Q)	<b>Terpene</b> (R)	<b>Trans</b> (S)	<b>Running</b> (T)	

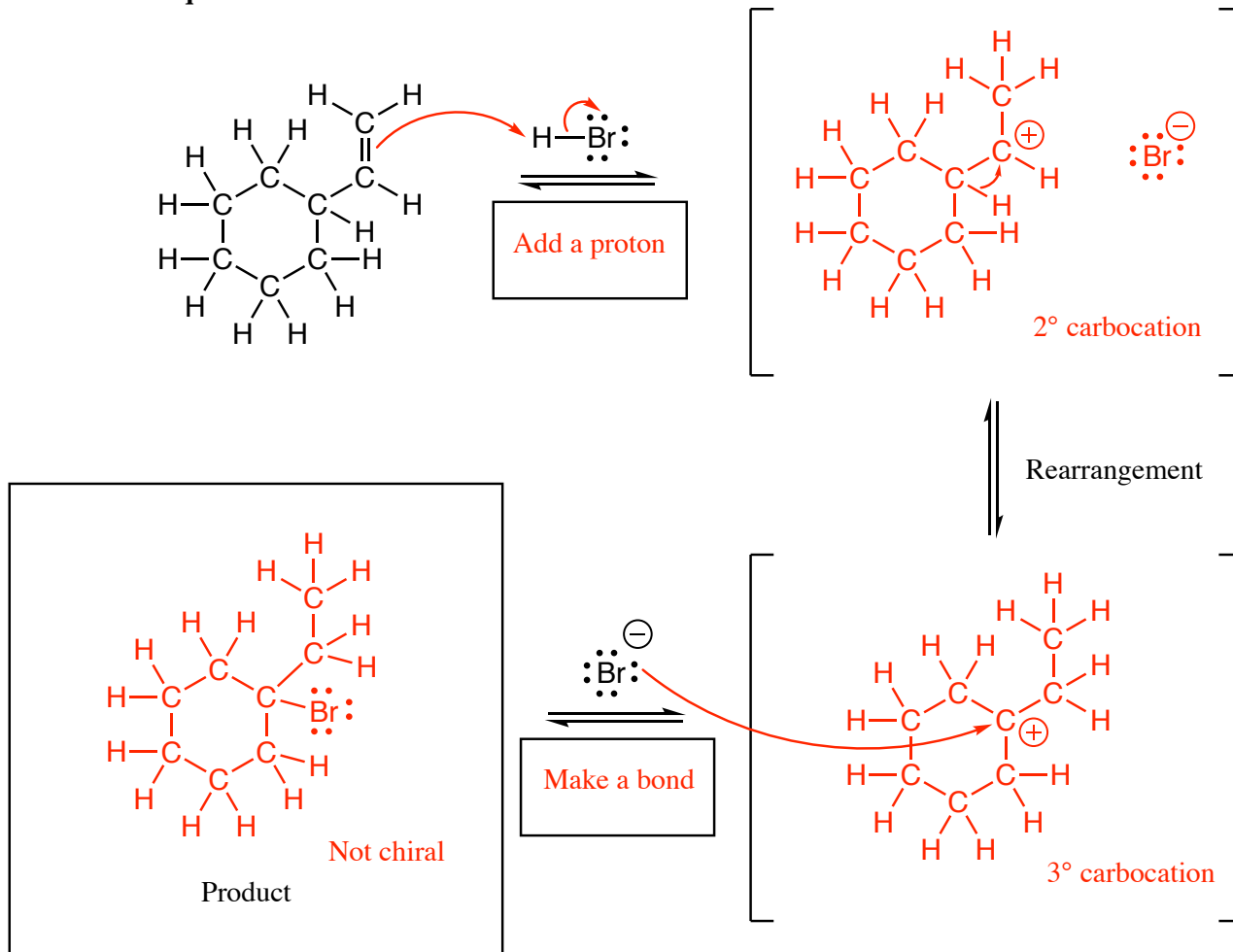
12. (20 pts) Complete the following four structures by adding appropriate numbers of lone pair electrons, H atoms, and formal charges to the atoms in the boxes. You must adjust your answers to indicate the predominant species at each indicated pH value. (You do not have to add anything such as H atoms to atoms not drawn in the boxes.) This problem is testing your understanding of the relationship of protonation state to pH to pKa values for certain functional groups we have discussed. Next, in the space provided, write the overall charge on each structure at the indicated pH. For your reference, here are the relevant pKa values:



13. (29 pts) Complete the following mechanism for the first step of each reaction. You are only completing the first step, not the entire reaction here. Use arrows to indicate the movement of all electrons and be sure to show all electron pairs and formal charges. **Note that you should only draw arrows on the structure to the left, not the intermediate.** YOU ONLY NEED TO DRAW ONE STEREOISOMER OF A CHIRAL INTERMEDIATE. IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR PRODUCT, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE.



14. (29 pts) Complete the mechanism for the following H-Br reaction with a rearrangement. **For this mechanism we will ONLY consider the rearranged product. Be sure to show arrows to indicate movement of all electrons, write all lone pairs, all formal charges, and all the products for each step.** Remember, I said all the products for each step. **YOU ONLY NEED TO DRAW ONE STEREOISOMER OF A CHIRAL INTERMEDIATE OR PRODUCT (using wedges and dashes as appropriate) IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR PRODUCT, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS “RACEMIC” IF APPROPRIATE.** In the two boxes provided under the arrows, write which of the 4 most common mechanistic elements describes each step (make a bond, break a bond, etc.). Be sure to notice the questions at the end.



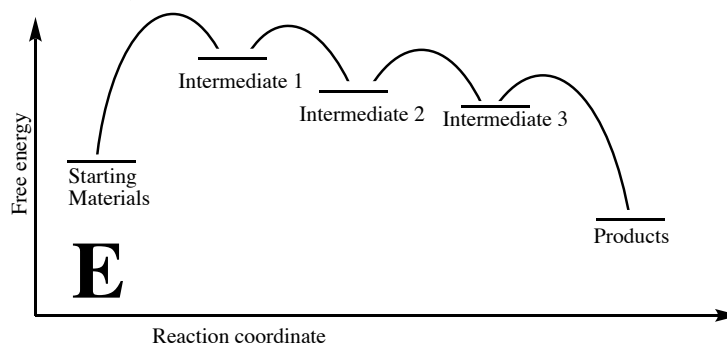
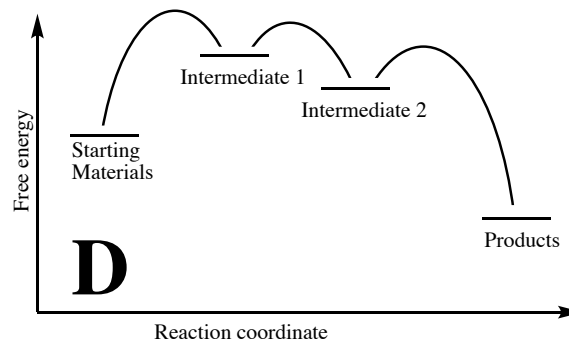
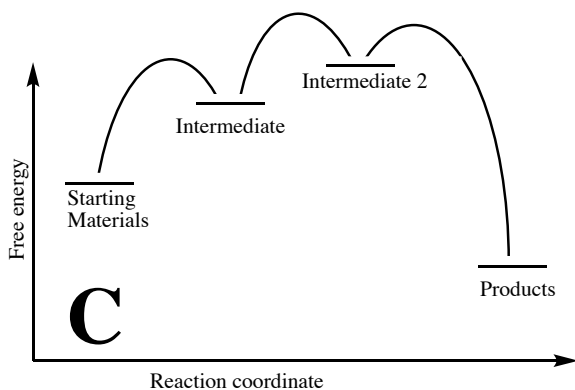
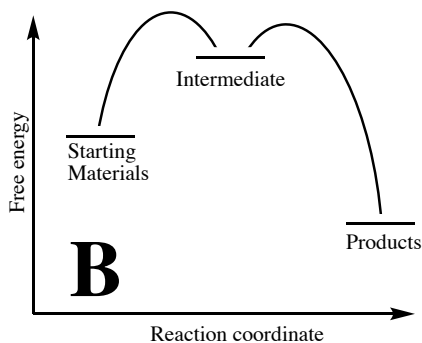
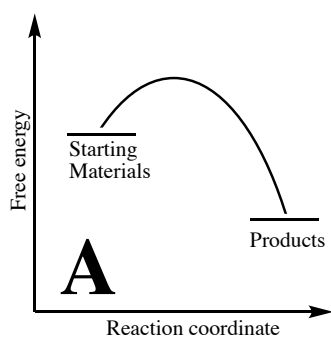
(2 pts) How many total stereoisomers are produced by this reaction? 1

(4 pts) Look at the energy diagrams on page 9. Write the letter of the one that best describes the above mechanism. D

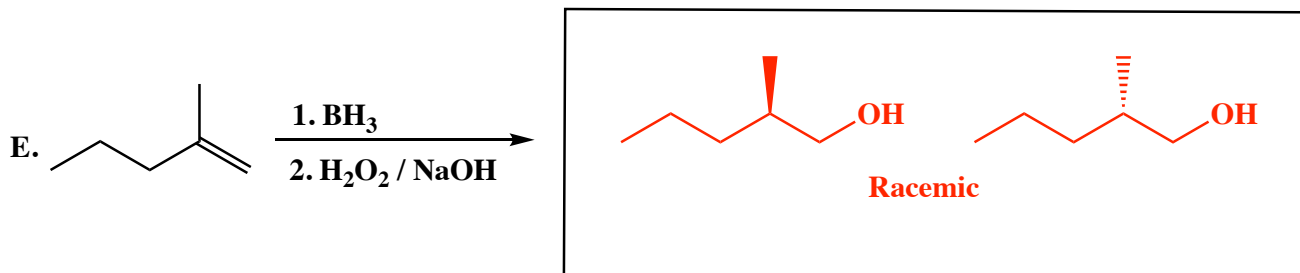
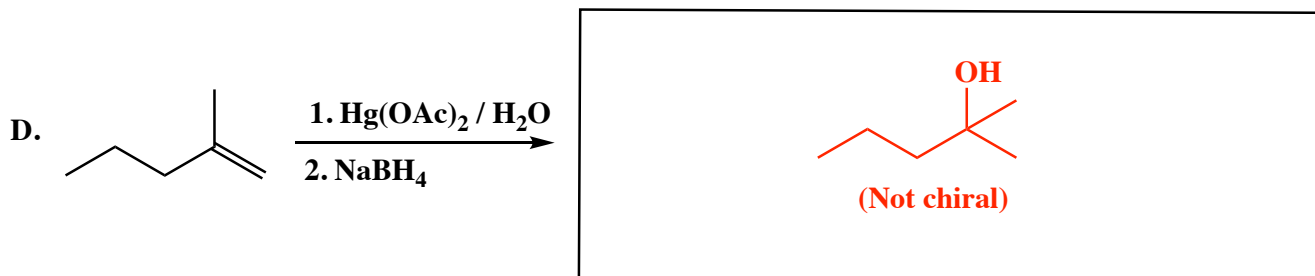
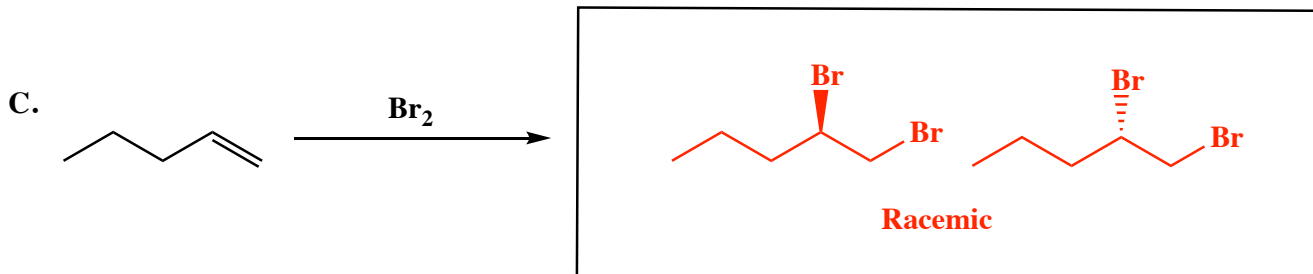
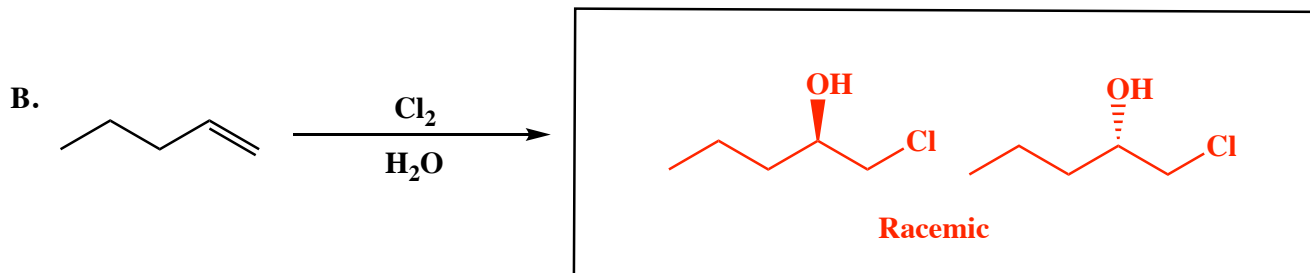
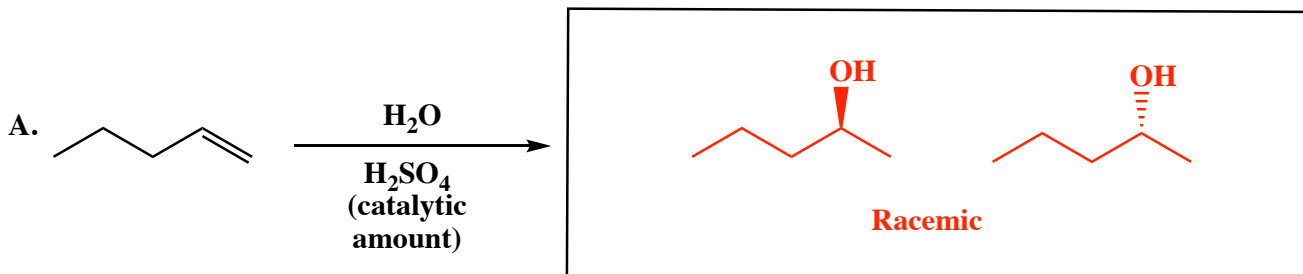
(2 pts) As the reaction proceeds, does the pH of the solution increase, decrease, or stay the same?

Increase (as we use up HBr)

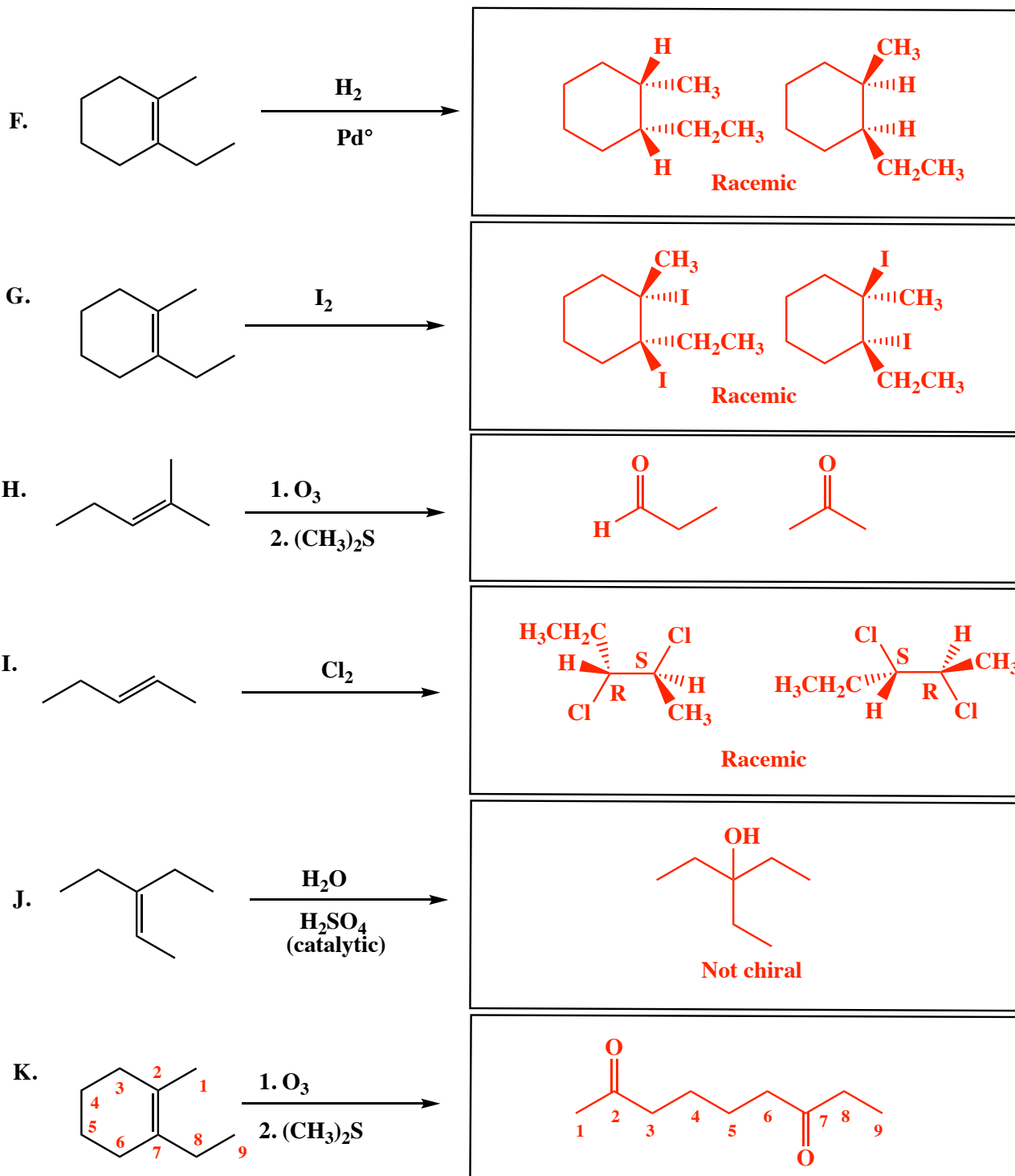
These energy diagrams refer to the mechanism your completed in problem 14 on pages 8. This page is not graded.



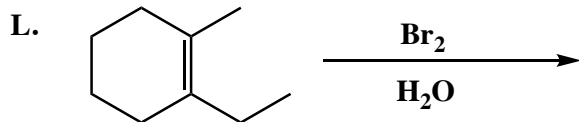
15. (3 or 5 pts each) The following reactions all involve chemistry of alkenes. Fill in the box with the product(s) that are missing from the chemical reaction equations. **Draw only the predominant regioisomer product or products** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry as appropriate**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.



15. (3,4, or 5 pts each) The following reactions all involve chemistry of alkenes. Fill in the box with the product(s) that are missing from the chemical reaction equations. **Draw only the predominant regioisomer product or products** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry when appropriate**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.

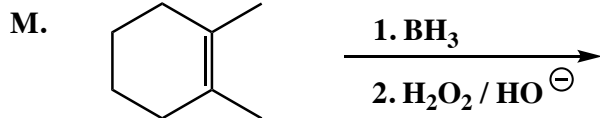
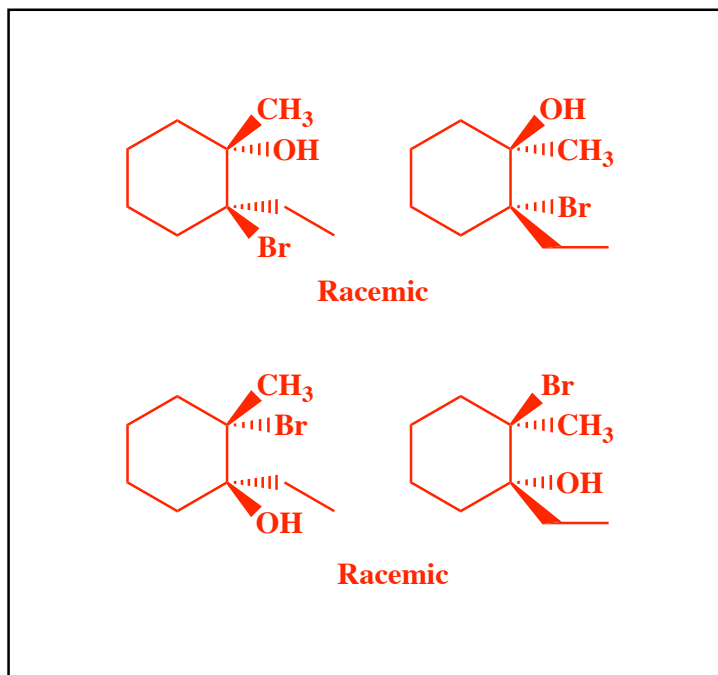


15. (7 or 11 pts each) The following reactions all involve chemistry of alkenes. Fill in the box with the product(s) that are missing from the chemical reaction equations. **Draw only the predominant regioisomer product or products if relevant** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry as appropriate**. When a racemic mixture is formed, **you must write "racemic"** under both structures **EVEN THOUGH YOU DREW BOTH STRUCTURES**.



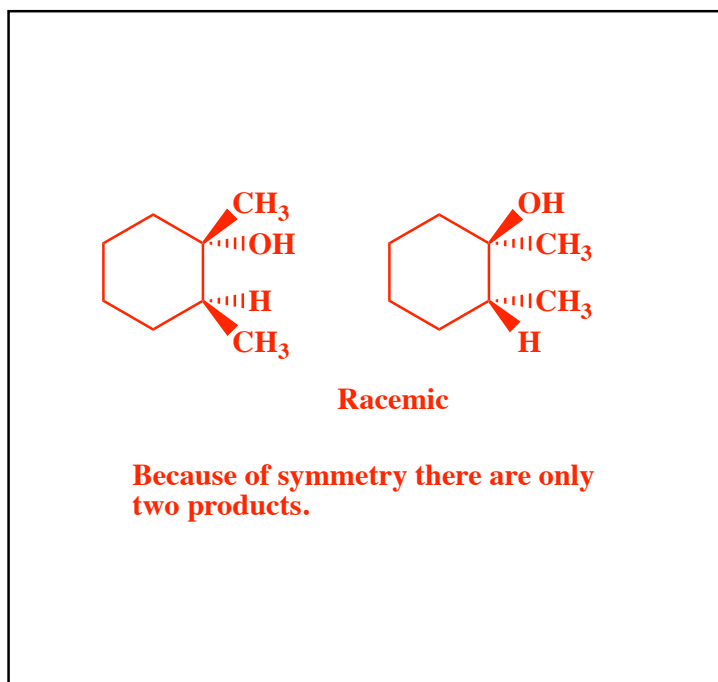
(2 pts) Will the product mixture you drew to the right rotate the plane of plane polarized light?

No



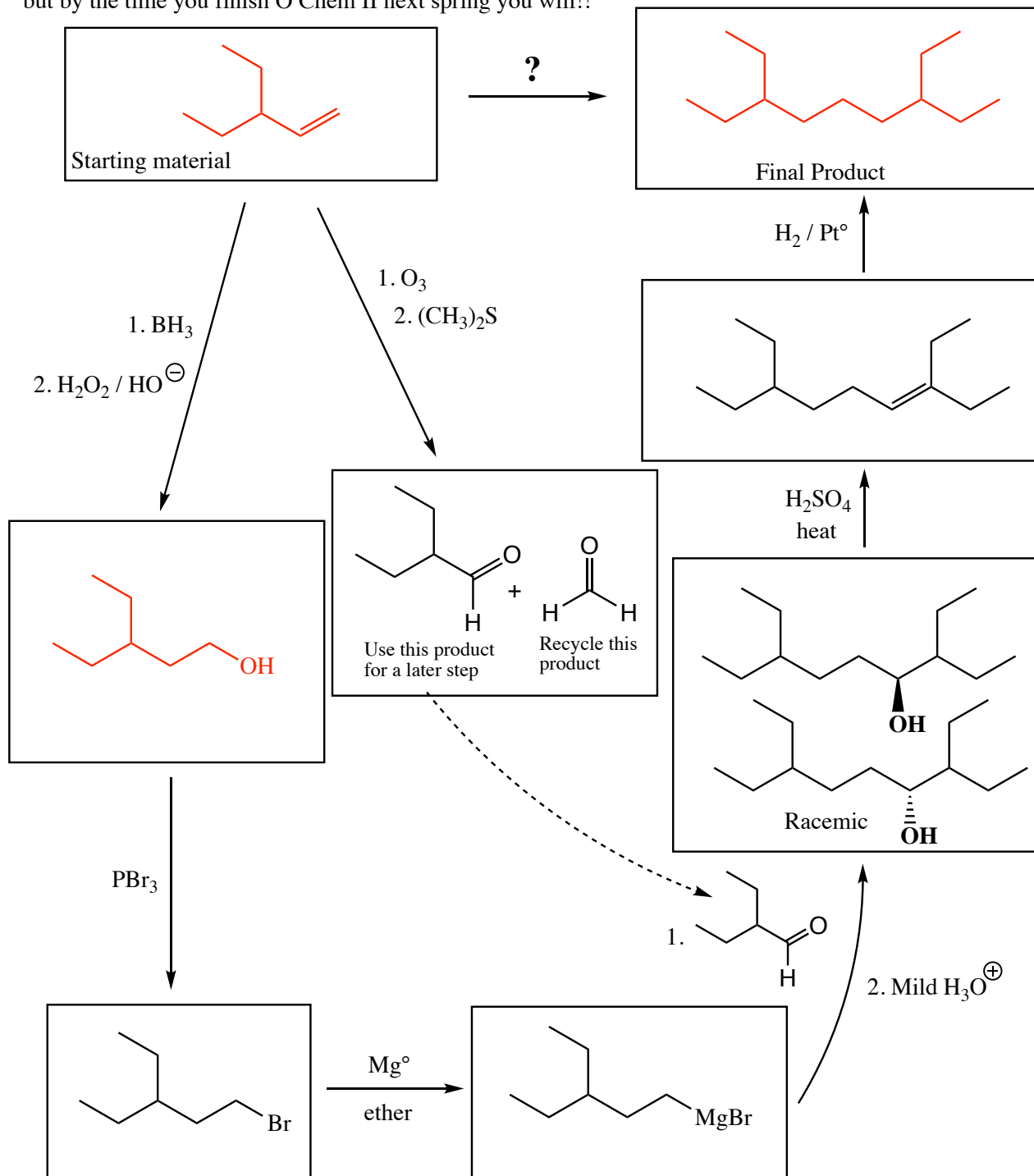
(2 pts) Will the product mixture you drew to the right rotate the plane of plane polarized light?

No

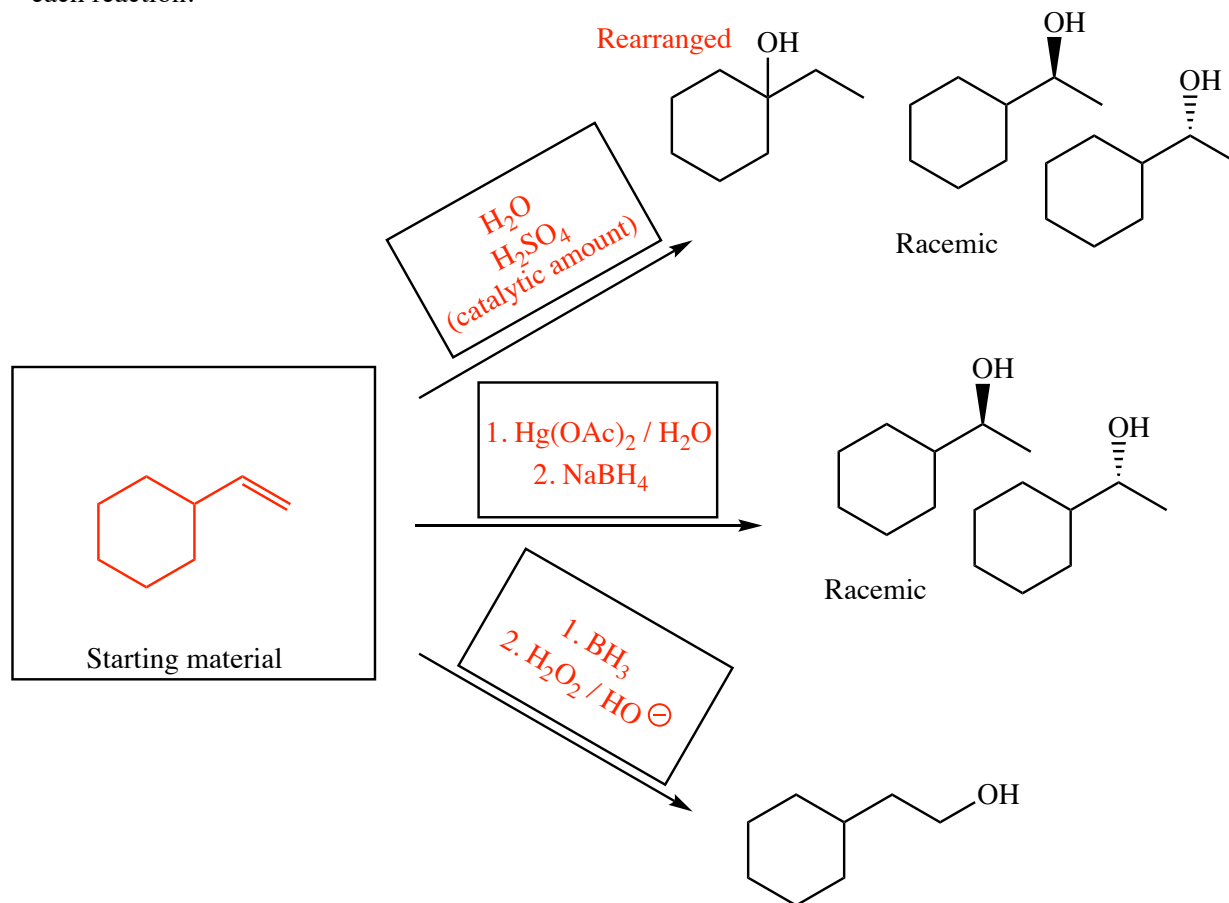




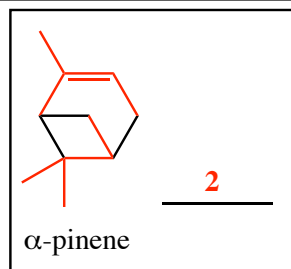
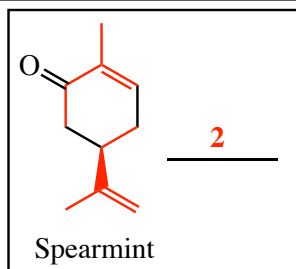
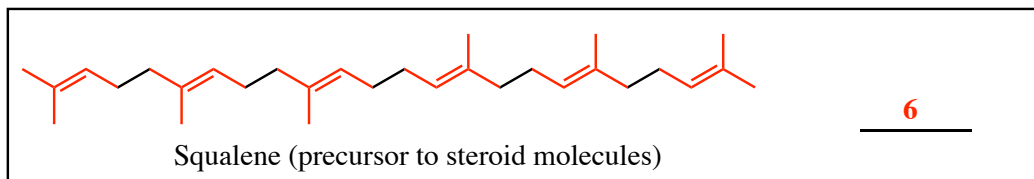
**16. (15 pts total) The point of organic chemistry is synthesis**, the conversion of simpler molecules to more complicated ones with enhanced structure and function. Each reaction you are learning should be thought of as a “tool” that allows you to create a desired type of molecule. These tools can be used in an almost infinite number of combinations to create truly interesting molecules. **In the boxes provided, draw the structures of the molecule indicated in this synthesis scheme.** FOR THIS ONE, IF STEREOISOMERS ARE CREATED YOU MUST DRAW THEM ALL USING WEDGES AND DASHES. And you must write “racemic” when appropriate. You will not recognize all of this chemistry, but by the time you finish O Chem II next spring you will!!



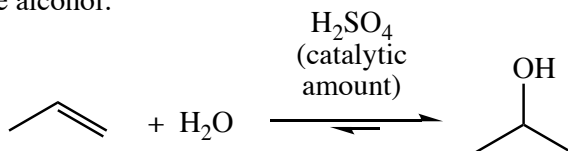
17. (9 pts total) It is important to think about reactions in both directions. To solve synthesis questions you will need to work backwards from a target molecule. All three reactions shown below use the same starting material. **Write the structure of that starting material in the box provided on the left, then write the appropriate reagents in the boxes over each arrow.** All observed products are shown for each reaction.



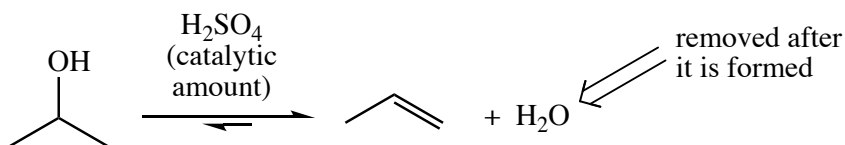
18. (6 pts total) On the line provided next to each terpene, **indicate the number of isoprene units contained within that structure.** You do not have to indicate where they are.



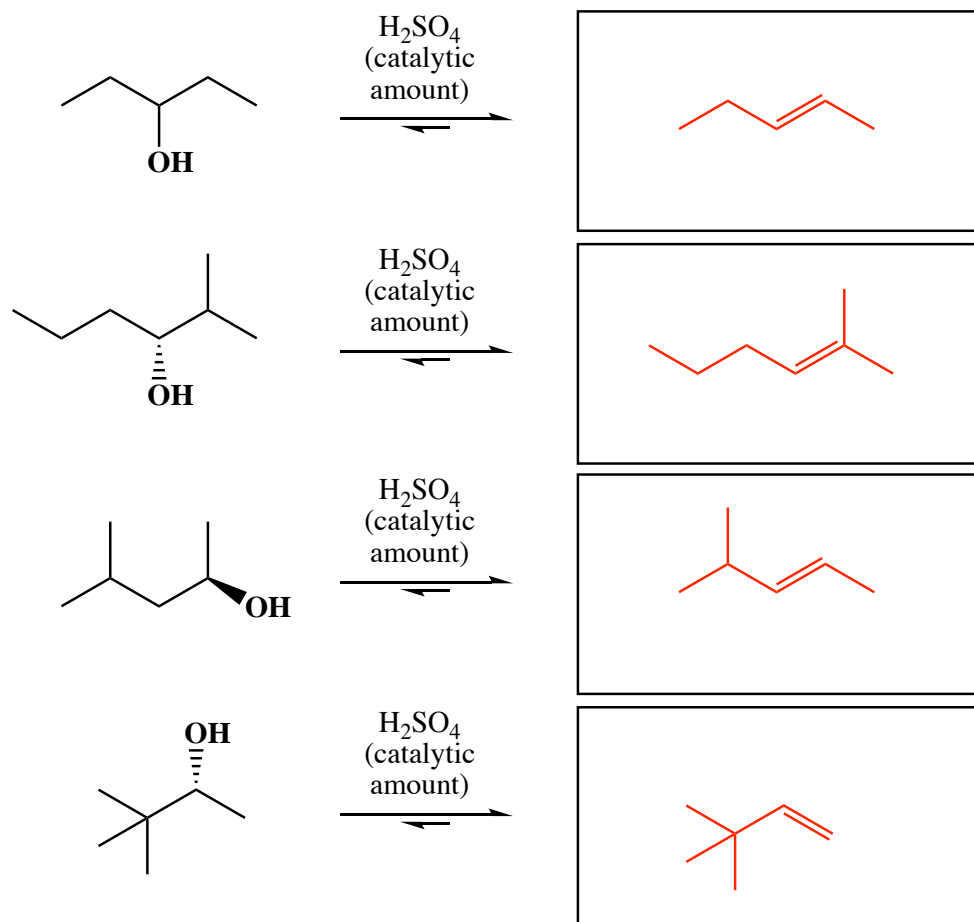
19. (16 pts) Here is an “apply what you know” question. You already know enough to answer this, but you will have to rely on your increasing chemical intuition to get all of the answers correct. Many chemical reactions are reversible. Chemists can modify the conditions of the reaction to favor equilibrium in either direction. You have already learned about your first useful reversible reaction, the acid-catalyzed hydration reaction of alkenes. If you place an alkene in excess water and add a catalytic amount of  $\text{H}_2\text{SO}_4$ , equilibrium favors formation of the alcohol.



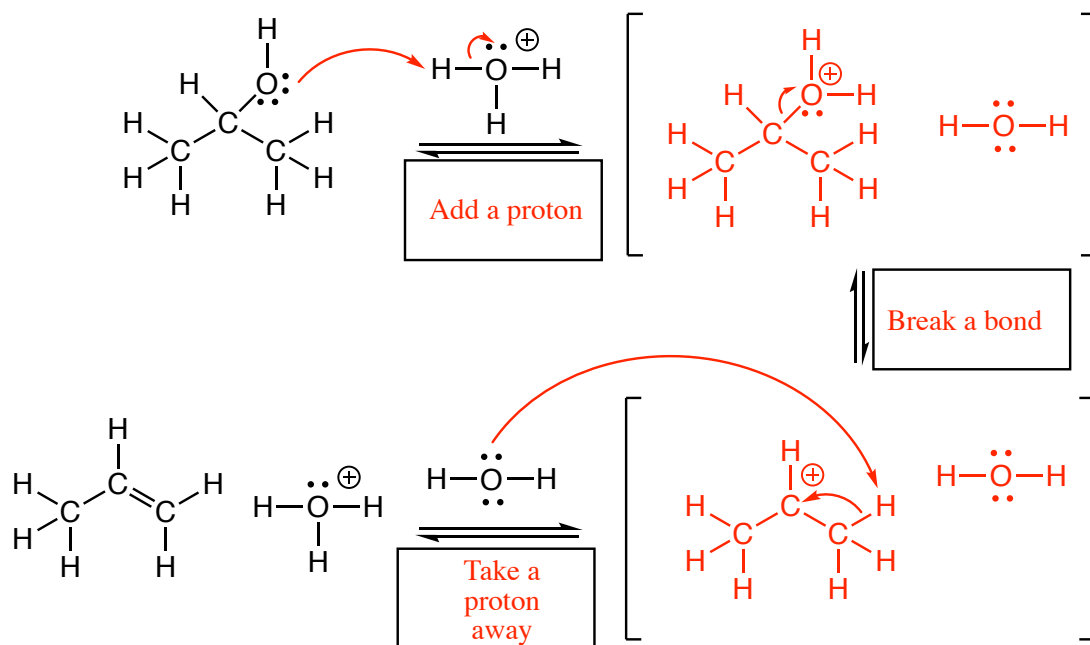
On the other hand, if you place an alcohol in the presence of a catalytic amount of  $\text{H}_2\text{SO}_4$  and remove water after it forms, equilibrium favors formation of the alkene.



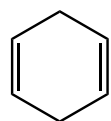
The key new idea is that when there is an option, the most stable possible alkene is created in this reaction. Use what you know about alkene stability to predict the predominant product of each reaction.



20. (15 pts) You will learn soon that reversible reactions follow the same mechanism in both directions. Think about that for a moment, then, use what you know about the acid-catalyzed hydration of alkenes to predict the mechanism of the reverse reaction. **Be sure to show arrows to indicate movement of all electrons, write all lone pairs, all formal charges, and all the products for each step.** Remember, I said all the products for each step. The two intermediates are identical to those in the alkene hydration reaction mechanism you learned (but in reverse order), so you know there is a carbocation in one of them! In the boxes provided next to each arrow, indicate which of the four most common mechanistic elements describe that step (make a bond, etc.)



21. (8 pts) Challenge question, save until the end. Fill in the box with the product(s) that are missing from the chemical reaction equation. **Draw only the predominant regioisomer product or products** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry when appropriate.** When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES.**



2 equivalents of  $\text{Br}_2$

