

**CHEM 8A, Organic Chemistry I**  
**Fall '19 FINAL EXAM (300 points)**

1 (45)	
2 (35)	
3 (40)	
4 (50)	
5 (40)	
6 (45)	
7 (45)	
<b>Total (300)</b>	
	%

Use your knowledge of organic chemistry conventions to answer each question in the proper manner (pay attention to detail). **Read each question carefully, keeping an eye out for parts of problems to skip.** You have 3 hours to complete the exam. You are welcome to use pre-built models. Make sure there are 7 pages of content in addition to this cover page. Write your last name and first initial on the top of each page *once instructed to start the exam.*

Keep your eyes on your own paper. Electronic devices of any kind are not allowed, including cell phones and calculators. Any student found using any additional resources including electronic devices, another student's exam, allowing another student to look at their exam, or communicating with another student will be removed from the exam room and may receive a zero on this assessment. Such an incident will be reported to the UCSC Judiciary Affairs Committee. Focus on conveying your own work, it's not worth the risk to cheat!

Read instructions, breathe, and imagine you're in the comfort of your home or the library simply working on homework problems ☺

1 <b>H</b> 1.008	2																18 <b>He</b> 4.0026
3 <b>Li</b> 6.94	4 <b>Be</b> 9.0122											5 <b>B</b> 10.81	6 <b>C</b> 12.011	7 <b>N</b> 14.007	8 <b>O</b> 15.999	9 <b>F</b> 18.998	10 <b>Ne</b> 20.180
11 <b>Na</b> 22.990	12 <b>Mg</b> 24.305	3	4	5	6	7	8	9	10	11	12	13 <b>Al</b> 26.982	14 <b>Si</b> 28.085	15 <b>P</b> 30.974	16 <b>S</b> 32.06	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.948
19 <b>K</b> 39.098	20 <b>Ca</b> 40.078	21 <b>Sc</b> 44.956	22 <b>Ti</b> 47.867	23 <b>V</b> 50.942	24 <b>Cr</b> 51.996	25 <b>Mn</b> 54.938	26 <b>Fe</b> 55.845	27 <b>Co</b> 58.933	28 <b>Ni</b> 58.693	29 <b>Cu</b> 63.546	30 <b>Zn</b> 65.38	31 <b>Ga</b> 69.723	32 <b>Ge</b> 72.630	33 <b>As</b> 74.922	34 <b>Se</b> 78.97	35 <b>Br</b> 79.904	36 <b>Kr</b> 83.798
37 <b>Rb</b> 85.468	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.906	40 <b>Zr</b> 91.224	41 <b>Nb</b> 92.906	42 <b>Mo</b> 95.95	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 <b>Sn</b> 118.71	51 <b>Sb</b> 121.76	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.29
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.33	57-71 *	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.84	75 <b>Re</b> 186.21	76 <b>Os</b> 190.23	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.38	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.98	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89-103 #	104 <b>Rf</b> (265)	105 <b>Db</b> (268)	106 <b>Sg</b> (271)	107 <b>Bh</b> (270)	108 <b>Hs</b> (277)	109 <b>Mt</b> (276)	110 <b>Ds</b> (281)	111 <b>Rg</b> (280)	112 <b>Cn</b> (285)	113 <b>Nh</b> (286)	114 <b>Fl</b> (289)	115 <b>Mc</b> (289)	116 <b>Lv</b> (293)	117 <b>Ts</b> (294)	118 <b>Og</b> (294)

\* Lanthanide series

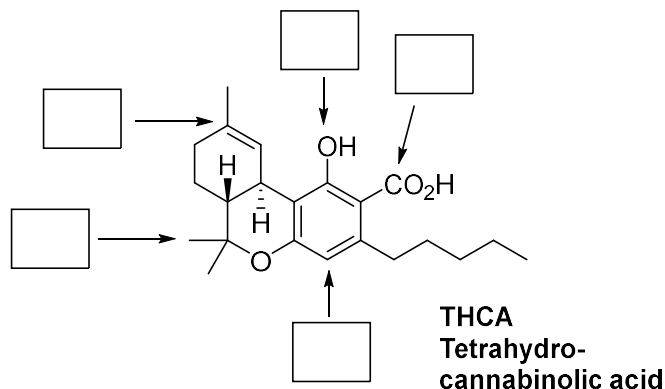
57 <b>La</b> 138.91	58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.36	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.93	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.05	71 <b>Lu</b> 174.97
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# Actinide series

89 <b>Ac</b> (227)	90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (262)
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## 1. FUNDamentals

(a) (10 points) **THC**, a commonly known psychoactive molecule from cannabis, is not directly synthesized by marijuana plants themselves. THC is the decarboxylation product of **THCA**. Indicate the **hybridization** of the indicated atoms.



(b) (10 points) Draw **structures** corresponding to any two of the following names.

*ortho*-bromophenol

*meta*-chlorobenzoic acid

5-ethyl-2,5-dimethyl-3-heptyne

(c) (10 points) The ultimate nomenclature problem!! Draw the **structure** for this name:

(2*R*, 5*S*, 6*E*)-5-benzyl-2-isopropyl-1-cyclopentyl-7-fluoro-9-phenyl-non-3-yn-6-ene

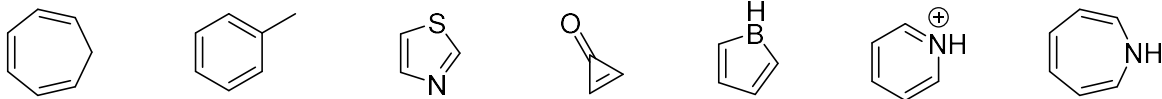
(d) (15 points) Draw a simple example of **your 3 favorite functional groups** (FG) below. They should be complete molecules containing at least 3 carbons without abbreviations such as R groups.

FG Name →			
Example →			

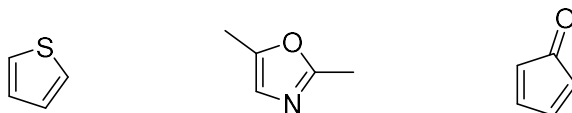
## 2. Structural Conventions & Analysis

Take 3 slow breaths or do 10 "flashlights" – hands open & close

(a) (10 points) Circle the aromatic compounds.



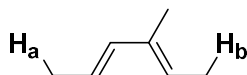
(b) (10 points) Draw all lone pair on O, S, and N. Indicate the number of pi electrons for each compound.



(c) (5 points) Provide the chemical name for each formula:

NaNH <sub>2</sub>	
BH <sub>3</sub>	
KOt-Bu	
H <sub>3</sub> O <sup>+</sup>	
HBr	

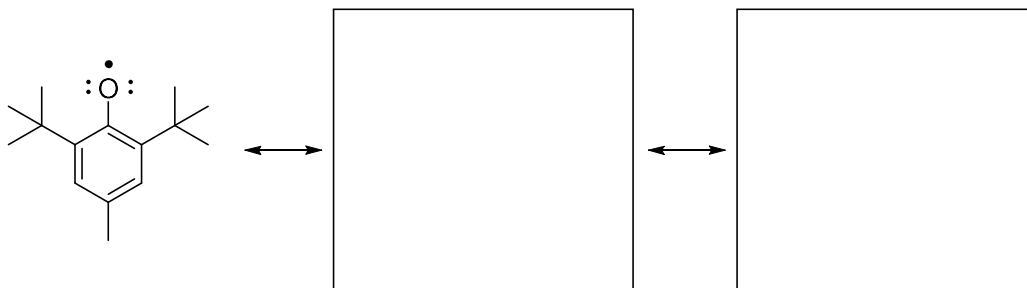
(e) (10 points) The C-H bonds to H<sub>a</sub> and H<sub>b</sub> exhibit very similar bond dissociation energies because homolytic cleavage of either bond results in a resonance-stabilized radical. Nevertheless, one of these C-H bonds is weaker than the other. Circle the weaker bond and briefly explain your choice with resonance structures.



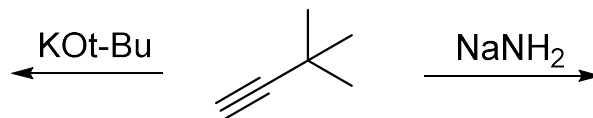
### 3. Arrow-Pushing / Reaction Warmup

Take 3 slow breaths or do 10 "flashlights" – hands open & close

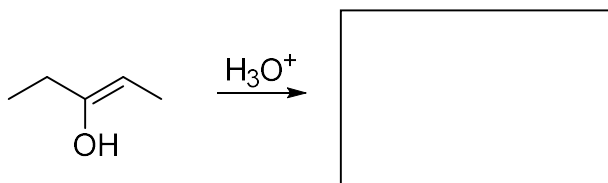
(a) (10 points) Butylated hydroxytoluene (BHT) is a food additive that can donate a proton and accept a free radical because it is stabilized by resonance. This prevents spoiling of vegetable oil, for example. Use **curved arrow notation** to show how the *radical moves by resonance* and **draw two resonance structures**.



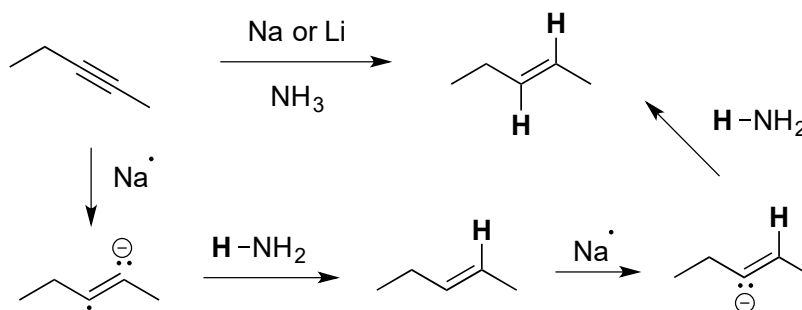
(b) (10 points) Only one of the reactions below proceeds to a reasonable extent. **Draw the products** of the reaction of the stronger base with the terminal alkyne. Add **curved arrow notation**. Leave the other reaction blank. *Hint: the pKa of t-butyl alcohol is 17 and the pKa of ammonia is 35.*



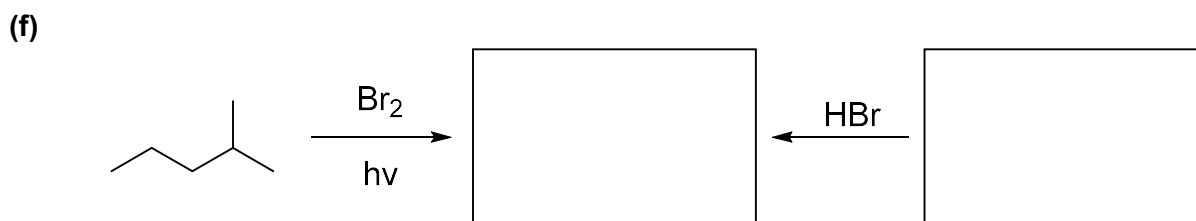
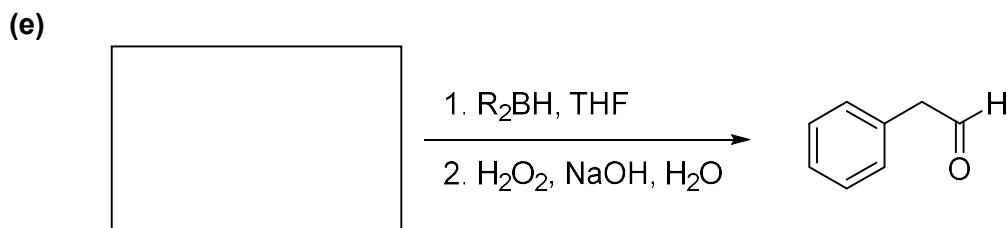
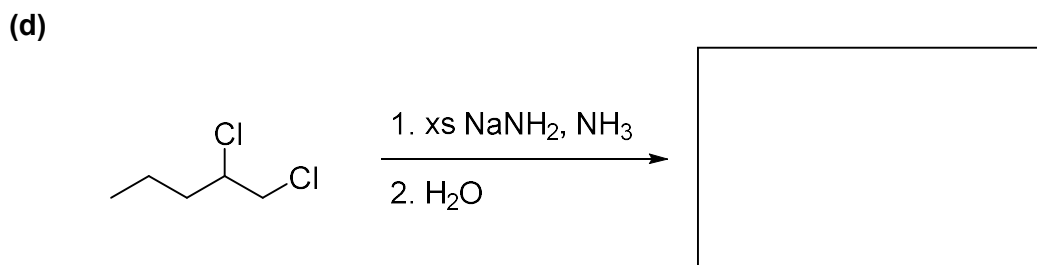
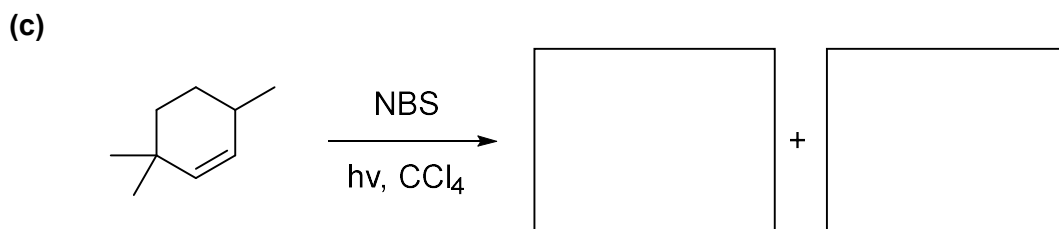
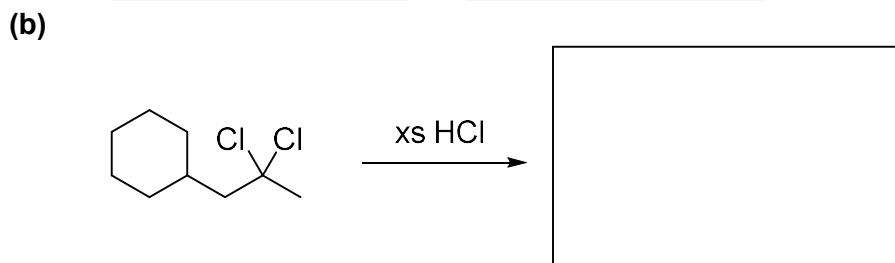
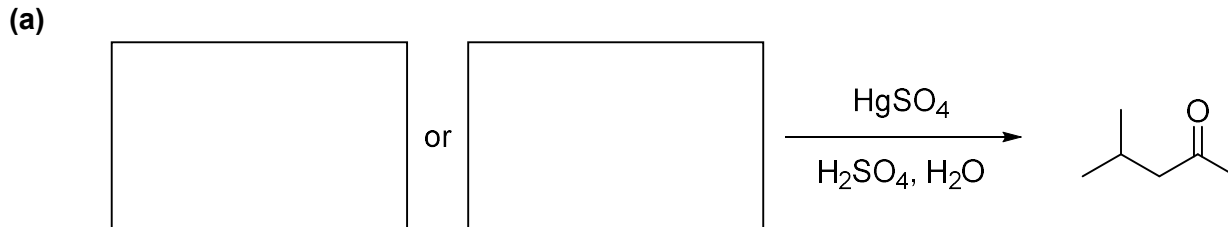
(c) (10 points) The following enol cannot be isolated. It rapidly tautomerizes to produce a ketone. Draw the expected ketone and show a **mechanism** for its formation under acid-catalyzed conditions (H<sub>3</sub>O<sup>+</sup>). Keep in mind there are several ways to correctly explain this mechanism in one or more steps – draw a single mechanism.



(d) (10 points) Use **curved arrow notation** to complete the following mechanism. This is a unique case where both double-headed and single-headed (fish hook) arrows are required. *Add arrows!*

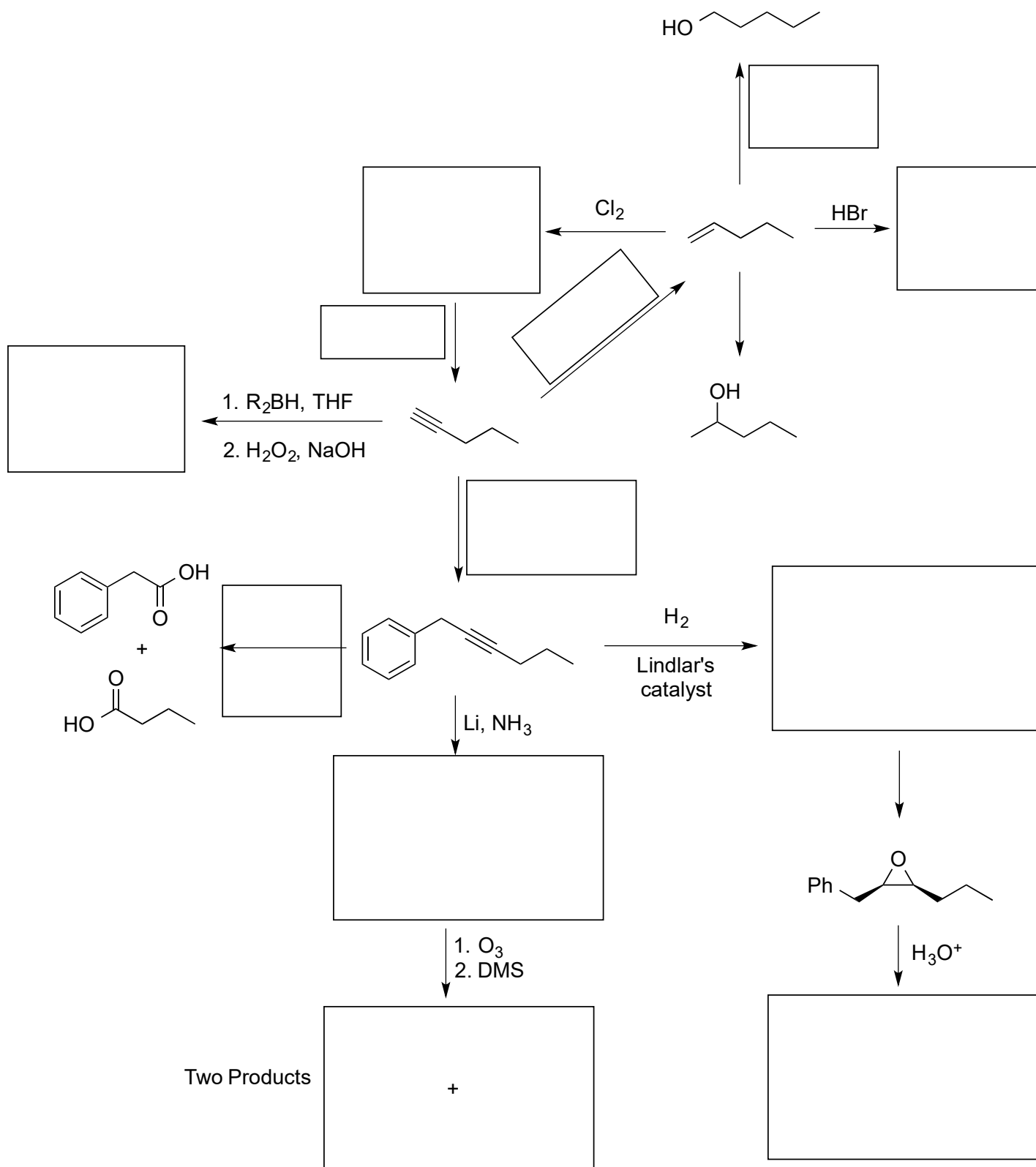


4. (50 points) **Single-Step Reactions: WHAT'S IN THE BOX?!?** Fill in the missing reactant, reagent, or product. Skip any one problem with a large X, otherwise (a) through (e) will be graded.



**SKIP ANY ONE PART BY DRAWING A LARGE X OVER THE BOX(ES).**

5. (40 points) **Reaction Puzzle** – Fill in the missing product or reactants in the boxes provided. You may leave any two boxes blank (or clearly 'X' them out) without penalty.

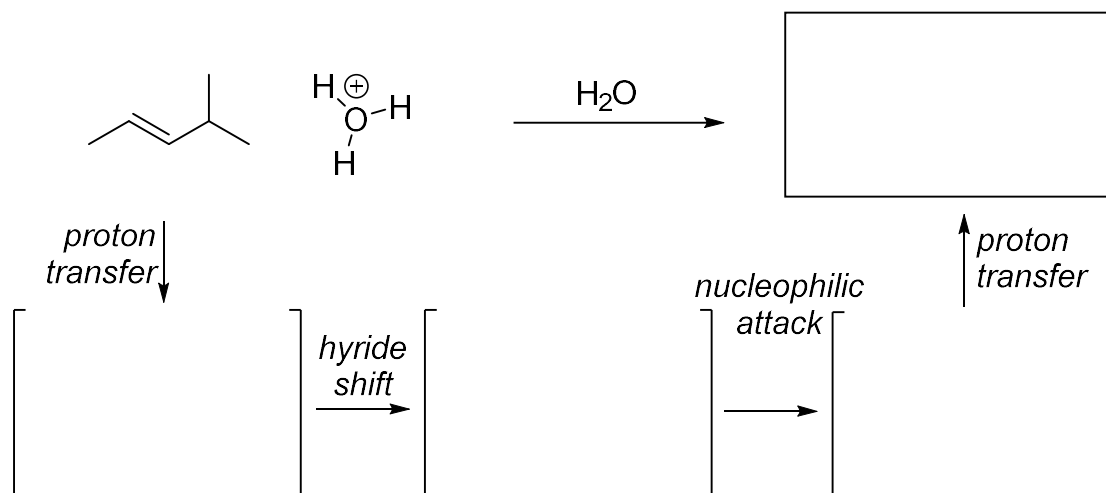


**6. Mechanisms**

(a) (10 points) Draw the **product** of the reaction below and the **radical intermediate** that is the basis for the regioselectivity in this reaction. **Briefly explain** how this radical promotes formation of the product. No arrows necessary.



(b) (20 points) Draw the **product, intermediates, and arrow-pushing mechanism** for the *acid-catalyzed hydration* of the alkene below. Arrow pushing pattern names are given as a guide.



(c) (5 points) Is the reaction above considered to be a **Markovnikov** or **anti-Markovnikov** addition? Briefly explain what that type of addition means and why it occurs in this mechanism.

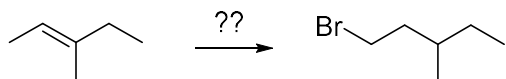
(d) (10 points) Draw the **mechanism, intermediate, and product** for this reaction. Use **curved arrow notation** and circle any formal charges.



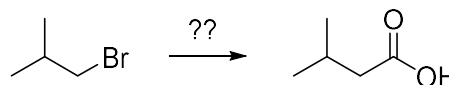
## 7. (45 points) Multi-Step Synthesis

**Choose any two** of the following synthesis problems. **Clearly cross out which problems you are skipping with a large "X."** Draw a snowman chemist under one of the problems you're skipping for 2 bonus points. Show the reagents and product after each step. If there is a mixture of products, assume the products are separable so you can move forward with the desired product. No mechanisms necessary.

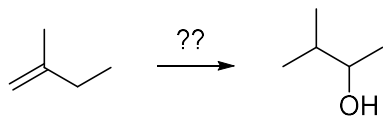
(a)



(b)



(c)



(d)

