

Name: \_\_\_\_\_ TA: \_\_\_\_\_

**CHEM 3331**  
**Dr. Minger**

**Midterm**  
**July 25, 2017**

**Step 1. Circle your recitation section and TA:**

- |     |            |     |             |
|-----|------------|-----|-------------|
| 211 | Brendan    | 221 | Matthew     |
| 212 | Aaron      | 222 | Ed          |
| 213 | Eric       | 223 | Rachel      |
| 214 | Will       | 224 | Jake (12pm) |
| 215 | Jake (3pm) |     |             |

**Step 2. Write your CU Student ID number here:** \_\_\_\_\_

**Step 3. Read and sign the Honor Code Statement:**

*I pledge that on my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this exam.*

\_\_\_\_\_  
Signature

**General Instructions:** There are 7 pages of questions plus this cover page. Be sure you have them all. **Read each question carefully so that you know exactly what is being asked.** Although the midterm is worth 100 points, this exam has 103 points possible (plus 10 points of extra credit). Good luck!

1A    2A    3A    4A    5A    6A    7A    8A

hydrogen																helium																					
1 <b>H</b>																2 <b>He</b>																					
1.0079																4.0026																					
lithium		beryllium														boron		carbon		nitrogen		oxygen		fluorine		neon											
3 <b>Li</b>		4 <b>Be</b>														5 <b>B</b>		6 <b>C</b>		7 <b>N</b>		8 <b>O</b>		9 <b>F</b>		10 <b>Ne</b>											
6.941		9.0122														10.811		12.011		14.007		15.999		18.998		20.180											
sodium		magnesium														aluminum		silicon		phosphorus		sulfur		chlorine		argon											
11 <b>Na</b>		12 <b>Mg</b>														13 <b>Al</b>		14 <b>Si</b>		15 <b>P</b>		16 <b>S</b>		17 <b>Cl</b>		18 <b>Ar</b>											
22.990		24.305														26.982		28.086		30.974		32.065		35.453		39.948											
potassium		calcium		scandium		titanium		vanadium		chromium		manganese		iron		cobalt		nickel		copper		zinc		gallium		germanium		arsenic		selenium		bromine		krypton			
19 <b>K</b>		20 <b>Ca</b>		21 <b>Sc</b>		22 <b>Ti</b>		23 <b>V</b>		24 <b>Cr</b>		25 <b>Mn</b>		26 <b>Fe</b>		27 <b>Co</b>		28 <b>Ni</b>		29 <b>Cu</b>		30 <b>Zn</b>		31 <b>Ga</b>		32 <b>Ge</b>		33 <b>As</b>		34 <b>Se</b>		35 <b>Br</b>		36 <b>Kr</b>			
39.098		40.078		44.956		47.867		50.942		51.996		54.938		55.845		58.933		58.693		63.546		65.39		69.723		72.61		74.922		78.96		79.904		83.80			
rubidium		strontium		yttrium		zirconium		niobium		molybdenum		technetium		ruthenium		rhodium		palladium		silver		cadmium		indium		tin		antimony		tellurium		iodine		xenon			
37 <b>Rb</b>		38 <b>Sr</b>		39 <b>Y</b>		40 <b>Zr</b>		41 <b>Nb</b>		42 <b>Mo</b>		43 <b>Tc</b>		44 <b>Ru</b>		45 <b>Rh</b>		46 <b>Pd</b>		47 <b>Ag</b>		48 <b>Cd</b>		49 <b>In</b>		50 <b>Sn</b>		51 <b>Sb</b>		52 <b>Te</b>		53 <b>I</b>		54 <b>Xe</b>			
85.468		87.62		88.906		91.224		92.906		95.94		[98]		101.07		102.91		106.42		107.87		112.41		114.82		118.71		121.76		127.60		126.90		131.29			
cesium		barium		lanthanum		hafnium		tantalum		tungsten		rhenium		osmium		iridium		platinum		gold		mercury		thallium		lead		bismuth		polonium		astatine		radon			
55 <b>Cs</b>		56 <b>Ba</b>		57-70 <b>* * *</b>		71 <b>Lu</b>		72 <b>Hf</b>		73 <b>Ta</b>		74 <b>W</b>		75 <b>Re</b>		76 <b>Os</b>		77 <b>Ir</b>		78 <b>Pt</b>		79 <b>Au</b>		80 <b>Hg</b>		81 <b>Tl</b>		82 <b>Pb</b>		83 <b>Bi</b>		84 <b>Po</b>		85 <b>At</b>		86 <b>Rn</b>	
132.91		137.33		[223]		174.97		178.49		180.95		183.84		186.21		190.23		192.22		195.08		196.97		200.59		204.38		208.98		[209]		[210]		[222]			
francium		radium		89-102 <b>* * *</b>		lanthanum		rutherfordium		dubnium		seaborgium		bohrium		hassium		meitnerium		darmstadtium		roentgenium		copernicium		nihonium		flerovium		tennessine		oganesson					
87 <b>Fr</b>		88 <b>Ra</b>		[223]		103 <b>Lr</b>		104 <b>Rf</b>		105 <b>Db</b>		106 <b>Sg</b>		107 <b>Bh</b>		108 <b>Hs</b>		109 <b>Mt</b>		110 <b>Uun</b>		111 <b>Uuu</b>		112 <b>Uub</b>		114 <b>Uuq</b>											
[223]		[226]		[223]		[262]		[261]		[262]		[269]		[269]		[268]		[271]		[272]		[277]		[289]													

\* Lanthanide series

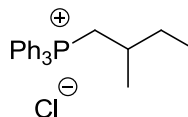
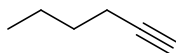
lanthanum	cerium	praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium
57 <b>La</b>	58 <b>Ce</b>	59 <b>Pr</b>	60 <b>Nd</b>	61 <b>Pm</b>	62 <b>Sm</b>	63 <b>Eu</b>	64 <b>Gd</b>	65 <b>Tb</b>	66 <b>Dy</b>	67 <b>Ho</b>	68 <b>Er</b>	69 <b>Tm</b>	70 <b>Yb</b>
138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium
89 <b>Ac</b>	90 <b>Th</b>	91 <b>Pa</b>	92 <b>U</b>	93 <b>Np</b>	94 <b>Pu</b>	95 <b>Am</b>	96 <b>Cm</b>	97 <b>Bk</b>	98 <b>Cf</b>	99 <b>Es</b>	100 <b>Fm</b>	101 <b>Md</b>	102 <b>No</b>
[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

\*\* Actinide series

Name: \_\_\_\_\_ TA: \_\_\_\_\_

1. **Extremely short answer.** Provide the requested information for each transformation. (10 pts)

a) Write the formulas of **three bases** that are used for quantitative deprotonations of each of these compounds.



1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_

b) Give ONE set of conditions (reagents, solvents, workup) that can be used to make an alcohol from a ketone.

\_\_\_\_\_

c) Write two specific methods/approaches that can be used to remove water from a reaction.

\_\_\_\_\_ or \_\_\_\_\_

d) State the purpose of using an acetal protecting group in a multi-step synthesis. One sentence only, not an essay. Use only the lines.

\_\_\_\_\_

\_\_\_\_\_

e) What kind of organic molecule is an organocuprate made from? (Two possible reasonable answers. Write only ONE)

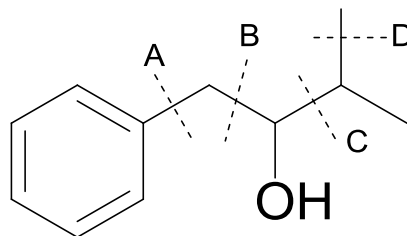
\_\_\_\_\_

f) What type of product results when you react an unstabilized phosphorous ylide with an aldehyde?

\_\_\_\_\_

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2. **Retrosynthesis.** (24 pts) Here is an alcohol with four different bond disconnections labeled (A, B, C and D).

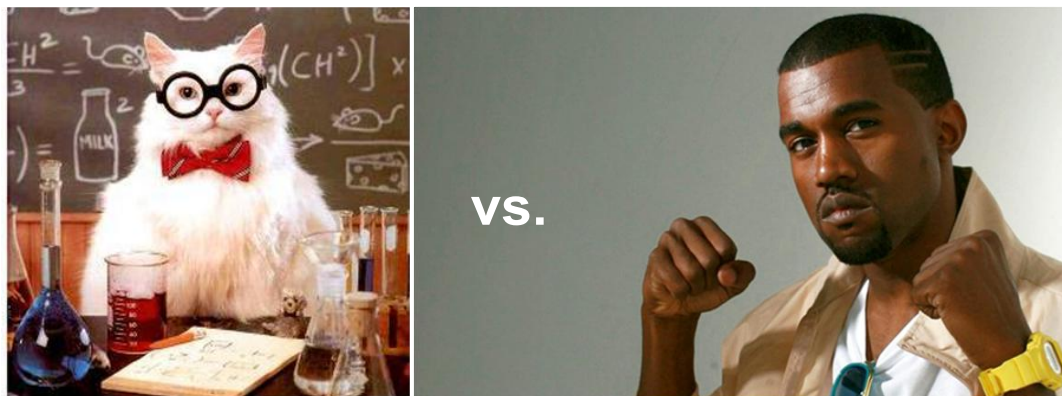


For each disconnection, indicate whether the alcohol could be made as the major product of one synthetic step (plus appropriate aqueous workup, which you should explicitly write where necessary).

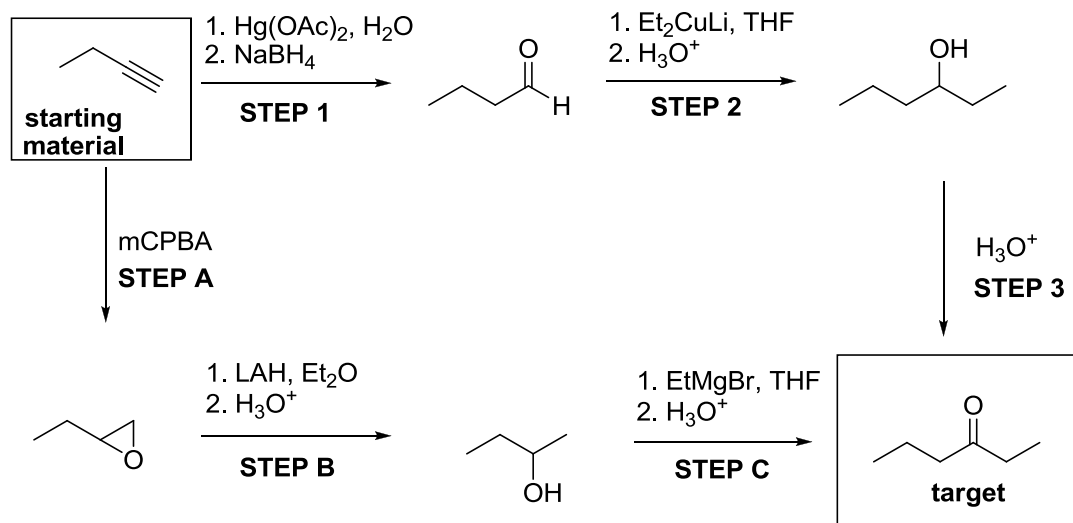
		Can alcohol be made successfully by making the indicated bond?	If "yes", draw reagents and precursor(s) here. If "no", explain why not.
<b>A</b>	$\implies$	___ Yes ___ No	<div style="border: 1px solid black; height: 80px; width: 100%;"></div>
<b>B</b>	$\implies$	___ Yes ___ No	<div style="border: 1px solid black; height: 80px; width: 100%;"></div>
<b>C</b>	$\implies$	___ Yes ___ No	<div style="border: 1px solid black; height: 80px; width: 100%;"></div>
<b>D</b>	$\implies$	___ Yes ___ No	<div style="border: 1px solid black; height: 80px; width: 100%;"></div>

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3. **Synthesis Showdown.** (18 pts) For the last few years, Kanye West has lost decisively to the Chemistry Cat in the world-famous Synthesis Showdown.



This year, determined to finally vanquish the Cat, Kanye outlined two different 3-step syntheses (Steps 1-3, and Steps A-C) in the hope that at least one of them would win. The starting material for each synthesis is 1-butyne (upper left) and the target is 3-hexanone (lower right).



Question continues on the next page.

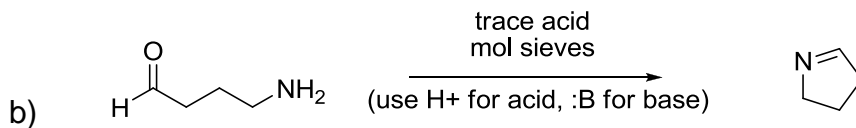
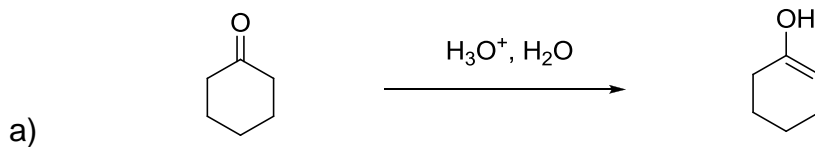
Name: \_\_\_\_\_ TA: \_\_\_\_\_

Analyze each of Kanye's two proposals (Steps 1 through 3, and Steps A through C). State whether each synthetic step, as proposed, would work. If not, indicate the reagents Kanye should use instead of the ones he has listed. Treat each step independently of the others; e.g., if the first step in a sequence doesn't work, just pretend it did when you examine the second step. If a particular step is impossible to do in ONE synthetic operation (i.e. ONE reaction, plus appropriate workup), just write "Not possible" in the third column.

<b>Step</b>	<b>Would it work as proposed?</b> <b>Circle Yes or No</b>	<b>If "No", what reagents should Kanye use?</b> <b>OR write "Not possible"</b>
<b>Step 1</b>	Yes    No	
<b>Step 2</b>	Yes    No	
<b>Step 3</b>	Yes    No	
<b>Step A</b>	Yes    No	
<b>Step B</b>	Yes    No	
<b>Step C</b>	Yes    No	

Name: \_\_\_\_\_ TA: \_\_\_\_\_

4. **Mechanism.** Draw a mechanism for each of the following transformations. Include all necessary curved arrows, lone pairs of electrons, and nonzero formal charges for full credit. If your drawings are unclear or ambiguous, you will lose points, so draw carefully! (24 pts)

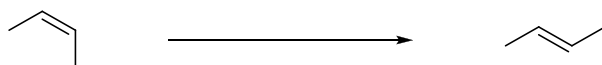


(Hint: This will be exactly the same mechanistic pattern that you would draw if the aldehyde and the amine were in separate molecules.)

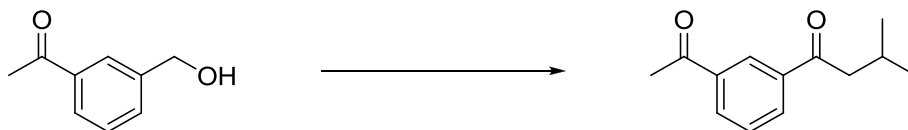
Name: \_\_\_\_\_ TA: \_\_\_\_\_

5. **Multi-step synthesis.** Propose a multi-step synthesis for each of the following transformations. Show the reagents needed for each step and the product of each step. Do not show any mechanisms. Do not just show a list of reagents without showing products or you will lose credit. If you use an organometallic reagent, you do not need to show how you made it. (27 pts)

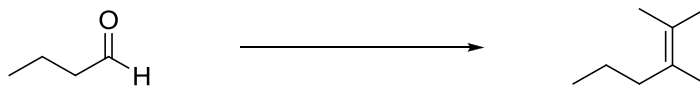
a)



b)



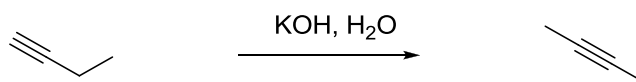
c)



Name: \_\_\_\_\_ TA: \_\_\_\_\_

6. **Extra credit.** (10 pts max) Do one or the other, but not both. No extra extra credit for doing both. Write your answer at the bottom of the page.

- a) Draw a mechanism to show the isomerization of the terminal alkyne to the internal alkyne using KOH as the base and water as the proton source. Include all lone pairs, curved arrows, and nonzero formal charges.



- b) Design two different multi-step syntheses of the target from the given starting material. Show the reagents needed for each step and the product of each step. Do not draw any mechanisms. Conditions: One synthesis must have an alkene as an intermediate. The other must have a carboxylic acid as an intermediate.

