

Please read and sign the Honor Code statement below:

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 25 questions. Be sure you have them all. Read each question carefully so that you know exactly what is being asked.

Each multiple choice question (1-25) is worth **4 points** and has **only one correct answer**. Bubble in your answers to these questions on the Scantron provided. **Only the Scantron will be graded, not anything that you write on the exam.**

At the end of the exam, turn in your Scantron and this signed cover sheet. You may keep the rest of the exam to check your answers against the key later.

Good luck!

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

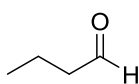
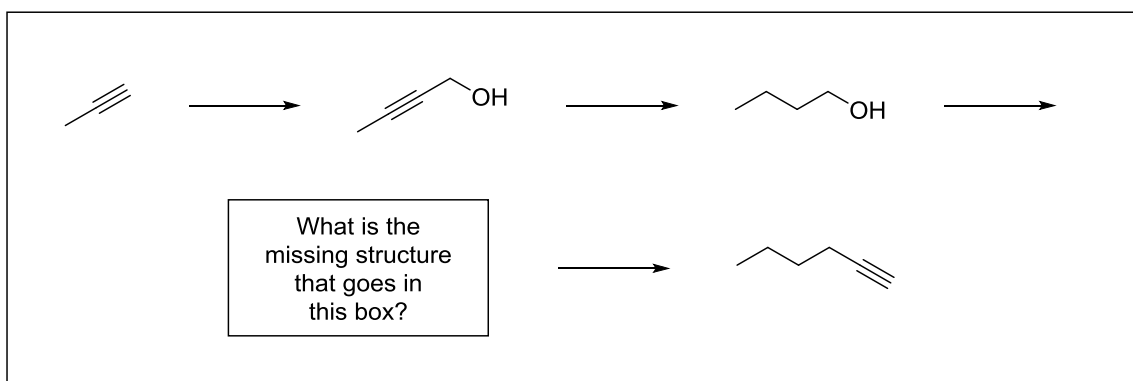
hydrogen 1 H 1.0079																								helium 2 He 4.0026										
lithium 3 Li 6.941	beryllium 4 Be 9.0122																								boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180				
sodium 11 Na 22.990	magnesium 12 Mg 24.305																								aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948				
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80																	
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	nickel 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29																	
cesium 55 Cs 132.91	barium 56 Ba 137.33	lanthanum 57-70 * Lu 174.97	hafnium 71 Hf 178.49	tantalum 72 Ta 180.95	wolfram 73 W 183.84	rhenium 74 Re 186.21	osmium 75 Os 190.23	iridium 76 Ir 192.22	platinum 77 Pt 195.08	gold 78 Au 196.97	mercury 79 Hg 200.59	thallium 80 Tl 204.38	lead 81 Pb 207.2	bismuth 82 Bi 208.98	polonium 83 Po [209]	astatine 84 At [210]	radon 85 Rn [222]																	
francium 87 Fr [223]	radium 88 Ra [226]	actinium 89-102 ** Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]																			

\* Lanthanide series

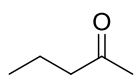
\*\* Actinide series

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

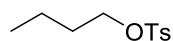
- Which of these reactions has an enol intermediate?
  - Anti-Markovnikov hydration of an alkene
  - Anti-Markovnikov hydration of an alkyne
  - Reduction of an alkyne using  $H_2$  and Lindlar's catalyst
  - Nucleophilic addition of an acetylide ion to formaldehyde
  - Ozonolysis
- Which of these bases would not quantitatively deprotonate acetylene?
  - NaH
  - NaOH
  - BuLi
  - LDA
  - Neither NaH nor NaOH would quantitatively deprotonate acetylene
- In this multi-step synthesis, what is the most likely choice for the missing intermediate?



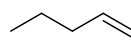
**A**



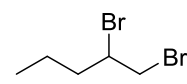
**B**



**C**

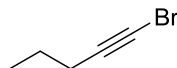
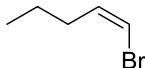
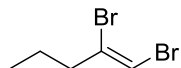
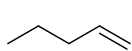
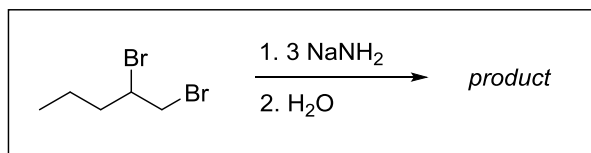


**D**



**E**

4. Which of these structures is an intermediate in the reaction described in the box?



None of these structures is an intermediate in the reaction

**A**

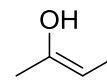
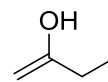
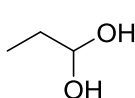
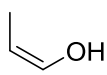
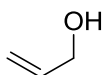
**B**

**C**

**D**

**E**

5. Select the structure that is the enol of an aldehyde.



**A**

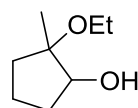
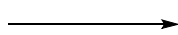
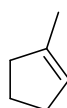
**B**

**C**

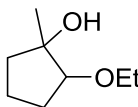
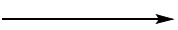
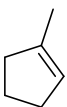
**D**

**E**

6. Here are two multi-step syntheses:



**Target A**

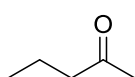
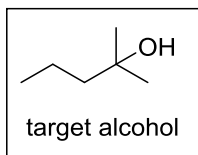


**Target B**

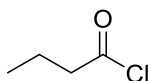
In which of these synthetic pathways is there a protonated epoxide?

- Synthesis of Target A
- Synthesis of Target B
- Both syntheses
- Neither synthesis

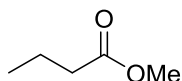
7. Which of the following structures is NOT a precursor to the target alcohol? ("Precursor" means you can make the alcohol in one synthetic step from the compound.)



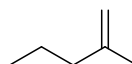
**A**



**B**



**C**



**D**

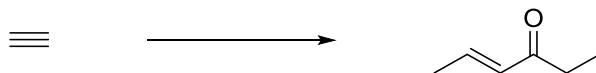
All of these compounds are precursors to the alcohol

**E**

8. Which of these reagents is NOT used to make a carbonyl compound?

- mCPBA
- $\text{HgSO}_4, \text{H}_2\text{SO}_4, \text{H}_2\text{O}$
- $(\text{Sia})_2\text{BH}$ , then  $\text{H}_2\text{O}_2, \text{HO}^-, \text{H}_2\text{O}$
- $\text{O}_3$ , then DMS
- $\text{O}_3$ , then  $\text{H}_2\text{O}_2$

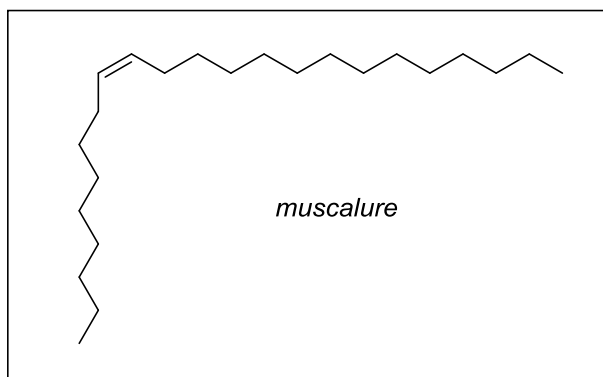
9. Consider this multi-step synthesis:



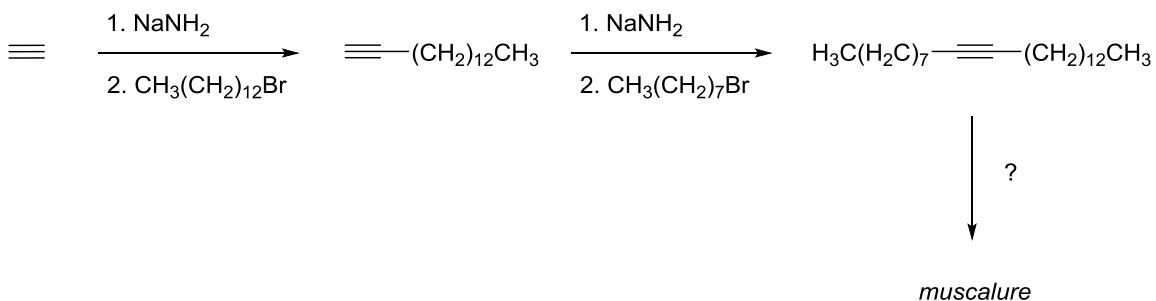
Which of the following reagents, based on the chemistry you know so far, must be used at some point in this synthesis?

- Jones reagent ( $\text{H}_2\text{CrO}_4$ , acetone, water)
- $\text{H}_2$  and Pd
- Na,  $\text{NH}_3$
- $\text{NaNH}_2$
- mCPBA

10. Bees use a form of motion called a “waggle dance” to communicate information to other bees about locations of pollen, water, or housing. The “waggle dance” involves flying in a particular pattern and direction. During the dance, a bee releases chemicals including the insect sex pheromone (9Z)-9-tricosene (muscalure). The structure of muscalure is shown here.



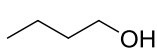
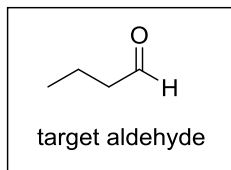
Muscalure can be synthesized according to the following scheme:



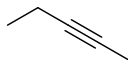
What is/are the missing reagent(s) in the last step?

- Na, NH<sub>3</sub>
- H<sub>2</sub>, Pd
- H<sub>2</sub>, Lindlar catalyst
- H<sub>2</sub>SO<sub>4</sub>, HgSO<sub>4</sub>, H<sub>2</sub>O
- None of the above

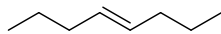
11. From which of these compounds can the target aldehyde NOT be made in one synthetic operation (including workup)?



**A**



**B**



**C**

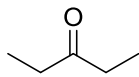
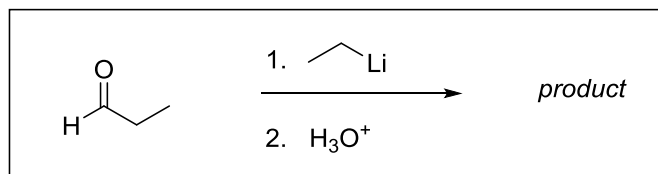


**D**

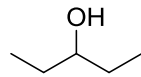
The aldehyde can be made from any of these compounds in one synthetic step

**E**

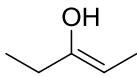
12. Select the structure that is the product of these reaction conditions.



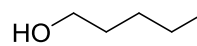
**A**



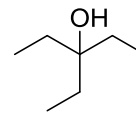
**B**



**C**

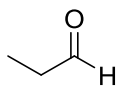


**D**

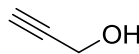


**E**

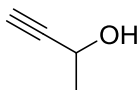
13. Which of these target molecules cannot be made in one step using an acetylide ion?



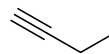
**A**



**B**



**C**

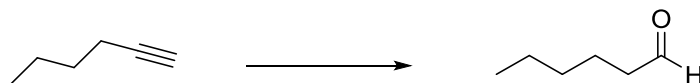


**D**

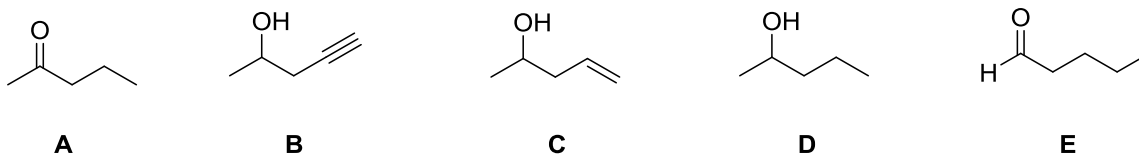
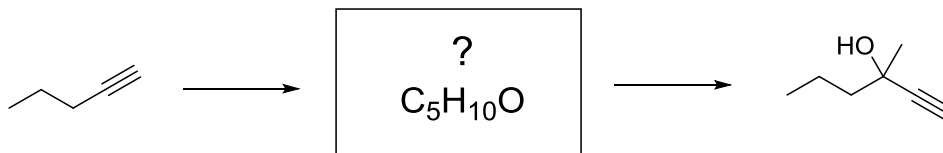
All of these compounds can be made from an acetylide ion

**E**

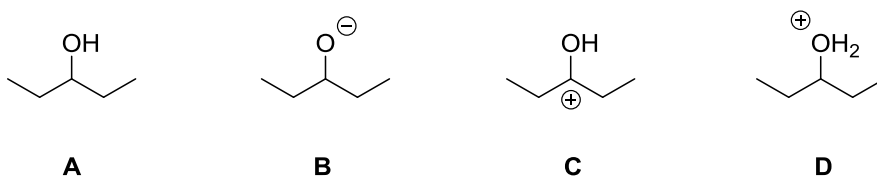
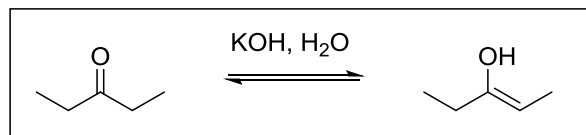
14. Which reagent would you use to convert 1-hexyne to hexanal?



- Na, NH<sub>3</sub>
  - H<sub>2</sub>, Pd, BaSO<sub>4</sub>, PbOAc, quinoline
  - MMPP
  - (Si<sub>3</sub>)<sub>2</sub>BH, then H<sub>2</sub>O<sub>2</sub>, HO<sup>-</sup>, H<sub>2</sub>O
  - H<sub>2</sub>CrO<sub>4</sub>, acetone, water
15. A compound with molecular formula C<sub>5</sub>H<sub>10</sub>O can be synthesized from the alkyne shown in one synthetic operation. This same compound can then be used to synthesize the alcohol at the right in one synthetic operation. What is the structure of the compound?



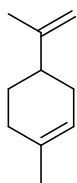
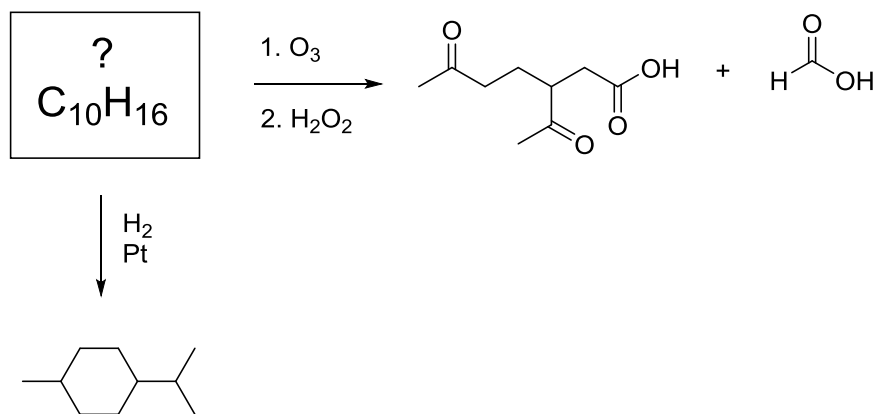
16. Select the structure that is a mechanistic intermediate in the tautomerization of this ketone in aqueous base.



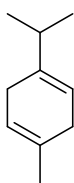
None of these structures are mechanistic intermediates

A B C D E

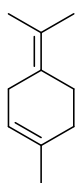
17. A compound with formula  $C_{10}H_{16}$  gives 1-isopropyl-4-methylcyclohexane when treated with hydrogen gas over platinum. The same compound produces the structure shown to the right, plus formic acid ( $HCOOH$ ), when treated with ozone followed by hydrogen peroxide workup. What is the structure of the compound?



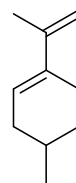
A



B



C

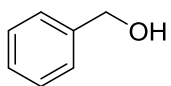


D

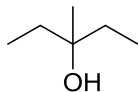
None of these

E

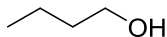
18. Which of these alcohols could be made from hydroboration-oxidation of an alkene?



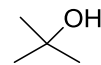
A



B



C



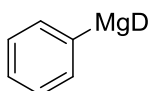
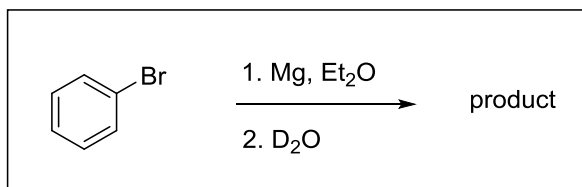
D

All of them

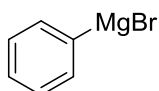
E



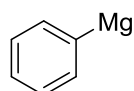
19. What is the product of the following reaction sequence?



**A**



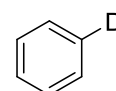
**B**



**C**

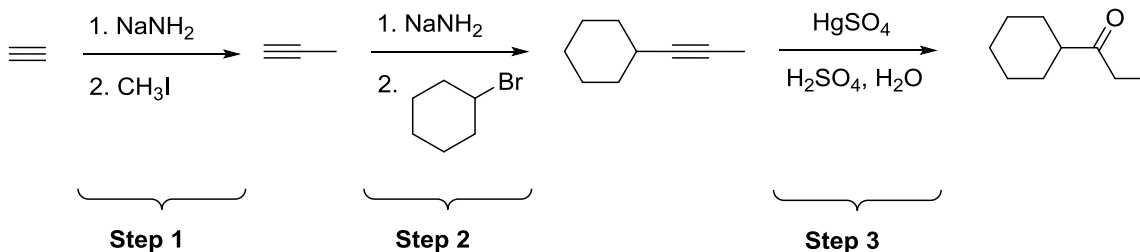


**D**



**E**

20. Selena Gomez has stated publicly that she dumped Justin Bieber because “that idiot doesn’t know anything about the chemistry of alkynes”. To prove her point, Selena points out that Justin thought that this synthesis would be successful:



Selena is basing her argument on the fact that at least one of the steps in the proposed synthesis would not give good yields of the product that Bieber is claiming, but in fact would give mixtures of products. Which steps have problems, according to Selena?

- Step 1
- Step 2
- Step 3
- Steps 2 and 3
- All three steps

For questions 21 through 25, use the following list to identify the reagent(s) that you would use to accomplish each transformation. Choices may be used more than once, or not at all.

- a. 1)  $\text{Hg}(\text{OAc})_2, \text{H}_2\text{O}$   
2)  $\text{NaBH}_4$
- b. 1)  $\text{O}_3$   
2) DMS
- c.  $\text{HBr}/\text{CH}_3\text{OOCH}_3/\text{heat}$
- d. Na or Li,  $\text{NH}_3$
- e. Can't be accomplished using any of these choices

