

*Key*

Name: \_\_\_\_\_ Student ID #: \_\_\_\_\_

**CIRCLE YOUR RECITATION SECTION and T.A.:**

- |     |         |     |         |
|-----|---------|-----|---------|
| 211 | Jessica | 221 | Aaron   |
| 212 | Lance   | 222 | Matthew |
| 213 | Tianyi  | 223 | Ethan   |
| 214 | Paula   | 224 | Dylan   |
| 215 | Brendan | 225 | Brendan |

**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 5 pages of questions. Be sure you have them all. Read each question carefully so that you know exactly what is being asked. Good luck!

1A 2A

3A 4A 5A 6A 7A 8A

1 H 1.00794																	2 He 4.00260						
3 Li 6.941	4 Be 9.0122																	5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305																	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 52.00	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.723	32 Ge 72.63	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80						
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc [98]	44 Ru 101.07	45 Rh 101.07	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29						
55 Cs 132.91	56 Ba 137.33	57-70 * Lanthanide series	71 Lu 174.967	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.084	79 Au 196.967	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.980	84 Po [209]	85 At [210]	86 Rn [222]					
87 Fr [223]	88 Ra [226]	89-102 ** Actinide series	103 Lr [260]	104 Rf [261]	105 Db [262]	106 Sg [263]	107 Bh [264]	108 Hs [265]	109 Mt [266]	110 Uun [267]	111 Uuu [268]	112 Uub [269]	114 Uuq [271]										

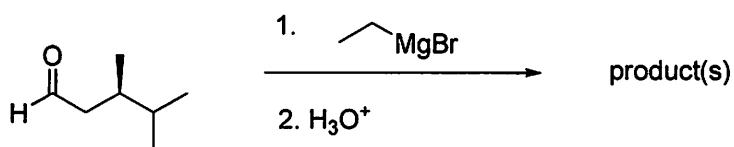
* Lanthanide series													
57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

Circle the single best answer to each of the multiple choice questions 1-5.  
(25 pts)

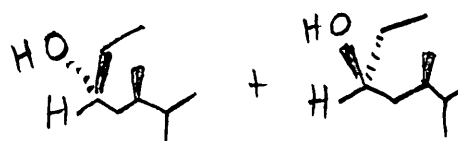
1. Which of the following shows the correct order of reactivity toward Grignard reagents (least reactive to most reactive)?

- C
- a. Aldehyde < Ketone < Ester
  - b. Ketone < Aldehyde < Ester
  - c. Ester < Ketone < Aldehyde
  - d. Ester < Aldehyde < Ketone
  - e. Ketone < Ester < Aldehyde

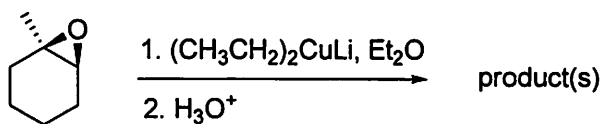
2. When the following reaction occurs, the product(s) will be:



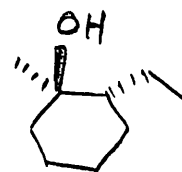
- a. a single achiral molecule
- b. a racemic mixture
- c. an unequal mixture of enantiomers
- d. an equal mixture of diastereomers
- e. an unequal mixture of diastereomers



3. When the following reaction occurs, the product(s) will be:

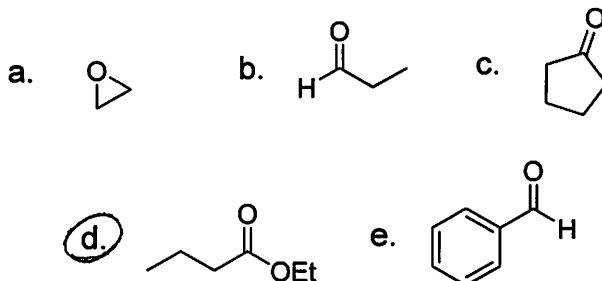


- a. a single achiral molecule
- b. a single chiral molecule
- c. a racemic mixture
- d. an equal mixture of diastereomers
- e. an unequal mixture of diastereomers



Name \_\_\_\_\_ TA \_\_\_\_\_ Student # \_\_\_\_\_

4. Which of these compounds requires two equivalents of a Grignard or organolithium reagent for complete reaction?

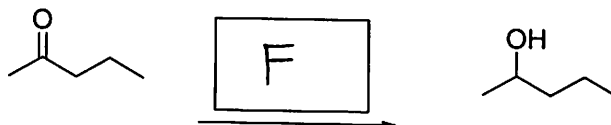
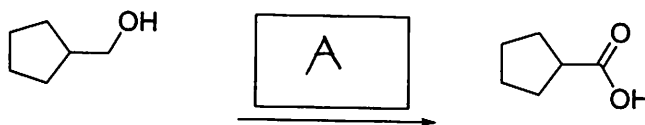
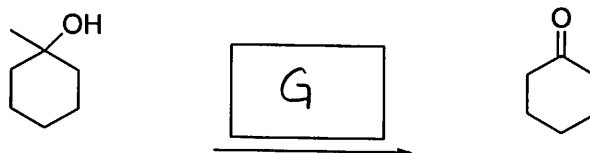
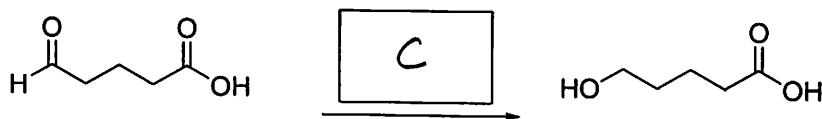
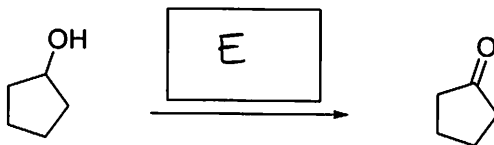


5. Using reactions you have seen in lecture, which of the following types of reagents cannot be used to synthesize a carboxylic acid from an appropriate organic starting material in one synthetic step (plus any necessary aqueous workup)?

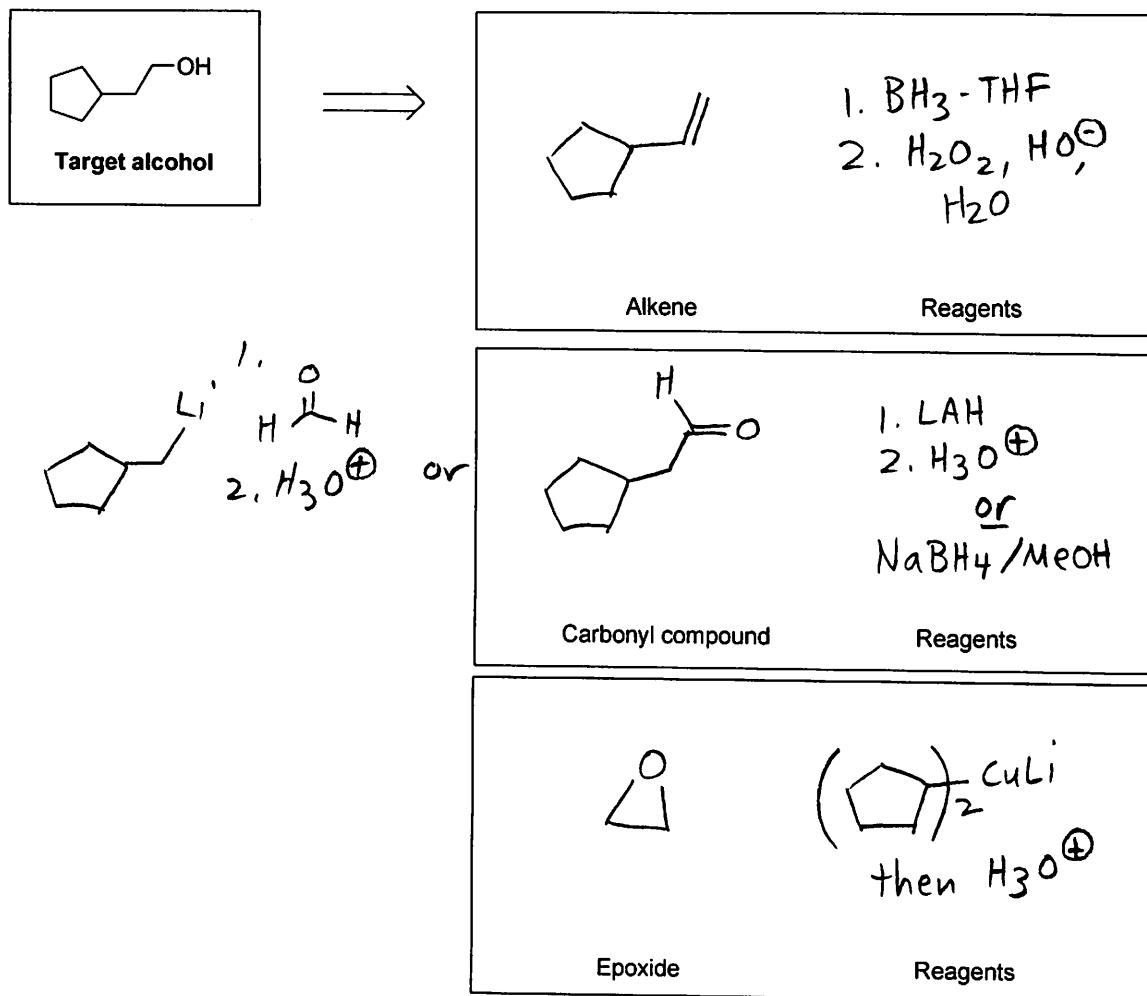
- B
- ✓ a. Grignard reagents with  $\text{CO}_2$ , then  $\text{H}_3\text{O}^+$
  - ✗ b. Organocuprates
  - ✓ c. Ozone, followed by hydrogen peroxide workup
  - ✓ d. Jones reagent using a  $1^\circ$  ROH or an aldehyde
  - e. All of these reagents can be used to produce carboxylic acids from appropriate starting materials in one step

6. **Oxidation and reduction.** For each of the following transformations, choose the correct reagent or reagents from the list. Assume that you can use as much of each reagent as necessary (i.e. 1 equivalent, 2 equivalents, etc) and that every reaction has an appropriate aqueous workup. You can use a reagent more than once, or not at all. Put the letter that corresponds to your choice in the box above each arrow. (30 pts)

- A Jones reagent ( $\text{H}_2\text{CrO}_4$ , acetone, water)  
 B PCC or PDC  
 C  $\text{NaBH}_4$   
 D LAH, then  $\text{H}_3\text{O}^+$   
 E A or B (either will work) (*Jones or PCC*)  
 F C or D (either will work) ( *$\text{NaBH}_4$  or LAH*)  
 G Cannot be accomplished using any of these choices.



7. **Alcohol retrosynthesis.** This target alcohol can be made from various combinations of organic substrate and reagents. Provide the structures of an alkene, a carbonyl compound, and an epoxide from which this alcohol can be made in one synthetic step, along with the necessary reagents to convert each of these precursors to the alcohol. (15 pts)



8. **Multistep synthesis.** (30 pts) For each of the following transformations, propose a synthesis of the target molecule from the starting material shown.

For full credit:

- Show reagents needed for each step and the product of each step. This means don't just write a list of reagents over the arrow and you will lose many points if you do it that way. The format should be  $A \rightarrow B \rightarrow C$ , with the reagents written over the arrow for each transformation.
- If you use an organometallic reagent, you do not need to show how you made it.

