Practice Sets
Organic Chemistry II
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- Online Organic Chemistry II, Chem 360,
- Dr. Craig P. Jasperse, Minnesota State University Moorhead
- For full class website, see
  - Fall/spring: https://collaborate.mnstate.edu/public/blogs/jasperse/online-organic-chemistry-courses/online-organic-chemistry-ii-360-fall-spring/
  - Summer: https://collaborate.mnstate.edu/public/blogs/jasperse/online-organic-chemistry-courses/online-organic-chemistry-ii-360-summer/
  - Face: https://collaborate.mnstate.edu/public/blogs/jasperse/on-campus-chemistry-courses/organic-chemistry-ii-360/

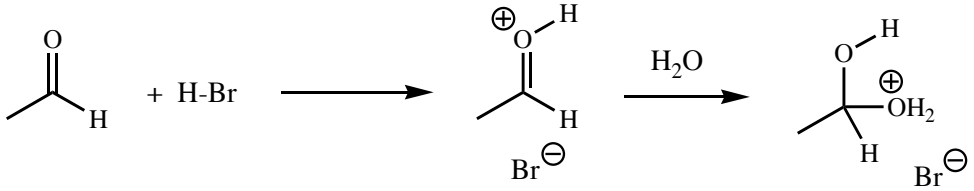
Test 1 PS#1: Arrow-Pushing/Mechanisms Practice Set

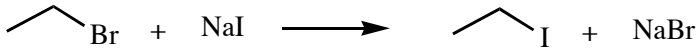
Chem 360 Name:

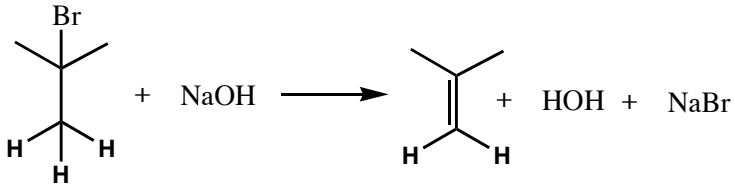
Jasperse Due:

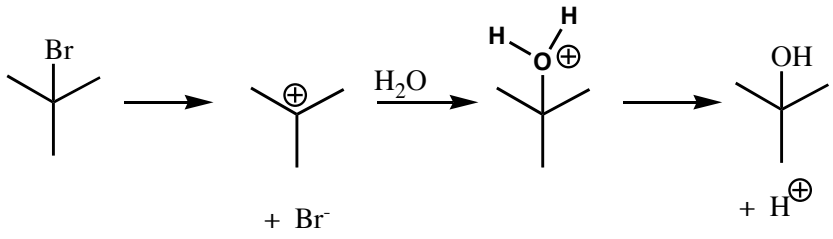
Arrow-Pushing Practice, Page 1:

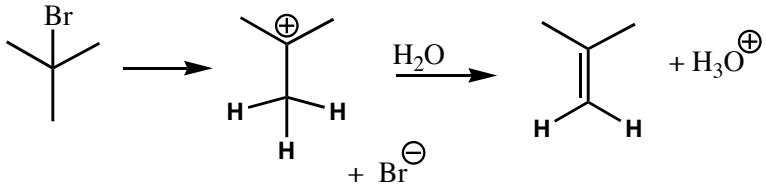
- Draw arrows for each of the steps in the following reactions.
- I won't require this on tests, but you may find it useful to include all lone-pairs on atoms that react.
- I won't require this on tests, but you may find it useful to draw in all hydrogens on atoms that react. (It is not useful to draw in all H's on atoms that don't react.)
- Remember that arrows track the movement of electrons, so an arrow should go from the source of electrons and point directly to the atom that accepts them.

1. (Old Test) 

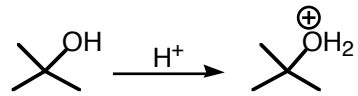
2. S_N2 

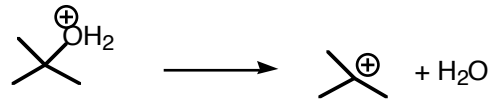
3. E2 

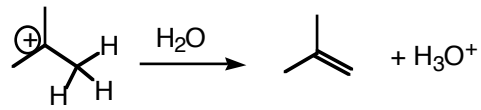
4. S_N1 

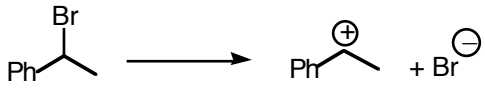
5. E1 

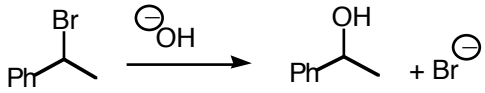
Page 2: Draw the arrow(s) for each of these steps.

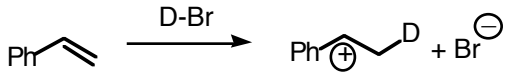
1. 

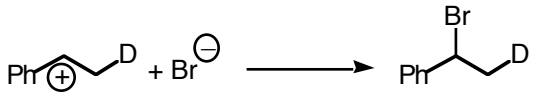
2. 

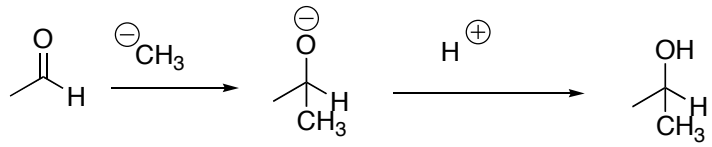
3. 

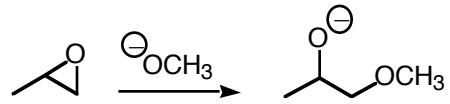
4. 

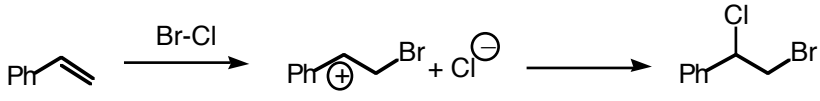
5. 

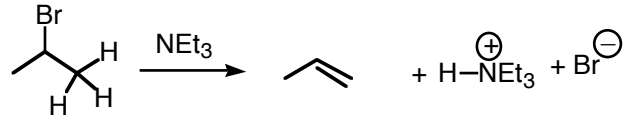
6. 

7. 

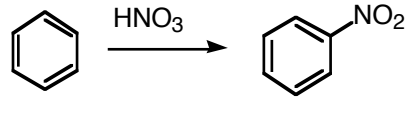
8. 

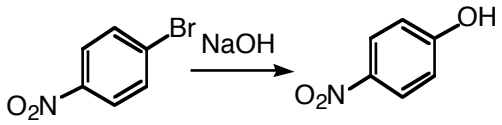
9. 

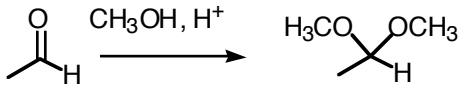
10. 

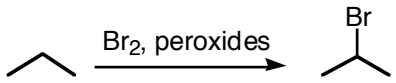
11. 

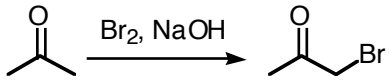
For each of the following reactions, write whether the mechanism would be radical, cationic, or anionic?

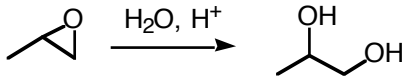
1. 

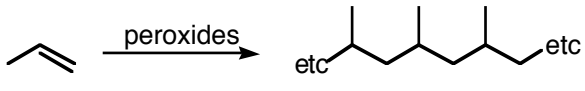
2. 

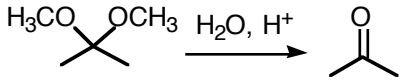
3. 

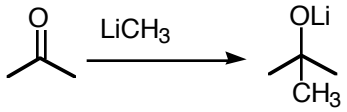
4. 

5. 

6. 

7. 

8. 

9. 

Some Arrow-Pushing Guidelines

1. Arrows follow electron movement.

2. Some rules for the appearance of arrows
   - The arrow must begin from the electron source. There are two sources:
     a. An atom (which must have a lone pair to give)
     b. A bond pair (an old bond that breaks)
   - An arrow must always point directly to an atom, because when electrons move, they always go to some new atom.

3. Ignore any Spectator Atoms. Any metal atom is always a "spectator"
   - When you have a metal spectator atom, realize that the non-metal next to it must have negative charge

4. Draw all H's on any Atom Whose Bonding Changes

5. Draw all lone-pairs on any Atom whose bonding changes

6. **KEY ON BOND CHANGES**. Any two-electron bond that changes (either made or broken) must have an arrow to illustrate:
   - where it came from (new bond made) or
   - an arrow showing where it goes to (old bond broken)

7. **Watch for Formal Charges and Changes in Formal Charge**
   - If an atom's charge gets more positive ⇒ it's donating/losing an electron pair ⇒ arrow must emanate from that atom or one of it's associated bonds. There are two "more positive" transactions:
     - When an anion becomes neutral. In this case, an arrow will emanate from the atom. The atom has donated a lone pair which becomes a bond pair.
     - When a neutral atom becomes cationic. In this case, the atom will be losing a bond pair, so the arrow should emanate from the bond rather than from the atom.

   - If an atom's charge gets more negative ⇒ it's accepting an electron pair ⇒ an arrow must point to that atom. Ordinarily the arrow will have started from a bond and will point to the atom.

8. **When bonds change, but Formal Charge Doesn't Change, A "Substitution" is Involved**
   - Often an atom gives up an old bond and replaces it with a new bond. This is "substitution".
   - In this case, there will be an incoming arrow pointing directly at the atom (to illustrate formation of the new bond), and an outgoing arrow emanating from the old bond that breaks

Organic Chemistry Jasperse Acid-Base Practice Problems

A. Identify each chemical as either an "acid" or a "base" in the following reactions, and identify "conjugate" relationships.

-You should have one acid and one base on each side

-You should have two conjugate pairs

1. $CH_3CH_2OH + NaOH \rightleftharpoons CH_3CH_2ONa + H_2O$

2. $CH_3CH_2NHLi + CH_3OH \rightleftharpoons CH_3CH_2NH_2 + CH_3OLi$

3. $CH_3CH_2CO_2H + CH_3MgBr \rightleftharpoons CH_3CH_2CO_2MgBr + CH_4$

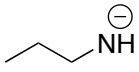
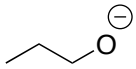
4. $CH_3OH + H_3O^+ \rightleftharpoons H_2O + CH_3OH_2^+$

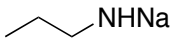
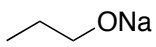
5. $CH_3CH_2NH_3^+ + CH_3OH \rightleftharpoons CH_3CH_2NH_2 + CH_3OH_2^+$

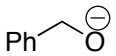
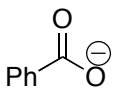
B. Choose the More **Basic** for Each of the Following Pairs (Single Variable). You can use stability to decide.

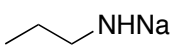
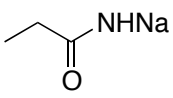
6. NH_3 $NaNH_2$

7. NaOH H_2O

8.  

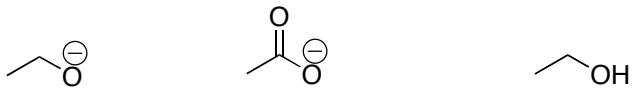
9.  

10.  

11.  

C. Rank the basicity of the following sets: Multiple Variable Problems

12. CH_3MgBr CH_3NHNa CH_3NH_2

13. 

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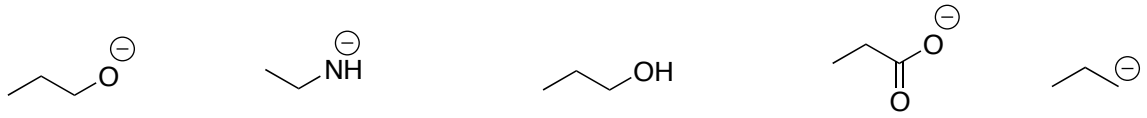
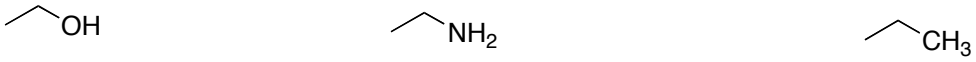
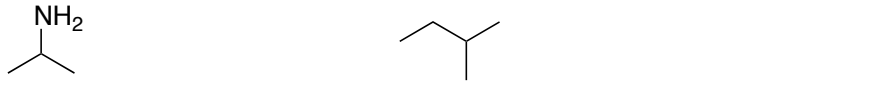
15. 

D. Choose the More Acidic for Each of the Following Pairs: Single Variable Problems

16. 

17. 

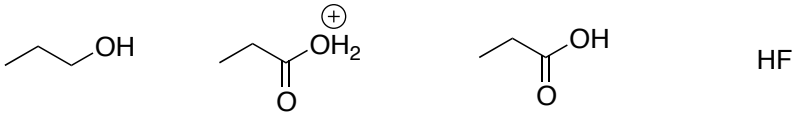
18. 

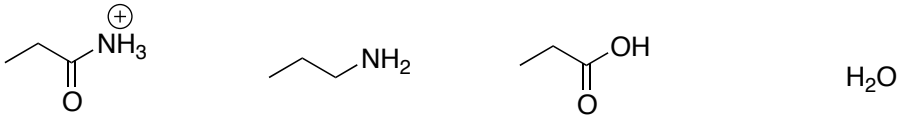
19. 

20. 

21. 

E. Rank the acidity of the following sets: Multiple Variable Problems

22. 

23. 

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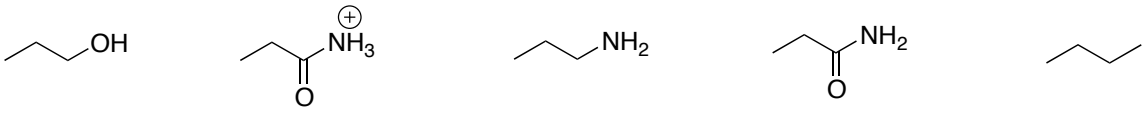
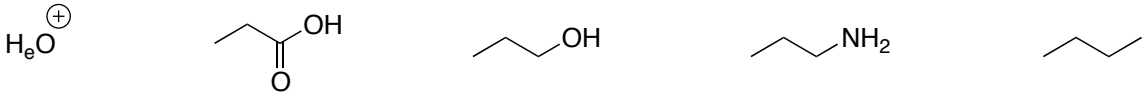
25. 

26. 

F. Draw arrow to show whether equilibrium favors products or reactants. (Why?)

27. 

28. 

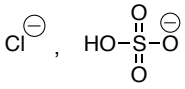
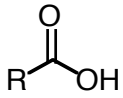
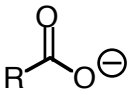
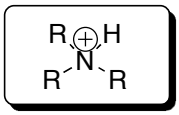
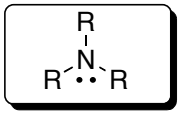
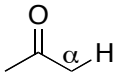
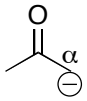
G. For the following acid-base reaction,
   a. put a box around the weakest base in the reaction
   b. put a circle around the weakest acid
   c. draw an arrow to show whether the equilibrium goes to the right or left. (4pt)

29. 

Test 1 PS#2: **Acid Base Practice Set**

Acid-Base Chemistry (Section 1.13-18)

Acidity/Basicity Table

Entry	Class	Structure	Ka	Acid Strength	Base	Base Strength
1	Strong Acids	H-Cl, H_2SO_4	10^2			
2	Hydronium	H_3O^+, ROH^+ cationic	10^0		H_2O, HOR neutral	
3	Carboxylic Acid		10^{-5}			
4	Ammonium Ion (Charged)	 Charged, but only weakly acidic!	10^{-12}		 Neutral, but basic!	
5	Water	HOH	10^{-16}			
6	Alcohol	ROH	10^{-17}			
7	Ketones and Aldehydes		10^{-20}			
8	Amine (N-H)	$(iPr)_2N$-H	10^{-33}			
9	Alkane (C-H)	RCH_3	10^{-50}			

Base Stability

Quick Checklist of Acid/Base Factors

1. Charge
2. **Electronegativity**
3. **Resonance/Conjugation**

1. Cations more acidic than neutrals; anions more basic than neutrals
2. Carbanions < nitrogen anions < oxyanione < halides in stability
3. resonance anions more stable than anions without resonance

- **When neutral acids are involved, it's best to draw the conjugate anionic bases, and then think from the anion stability side.**

- The above three factors will be needed this semester. The following three will also become important in Organic II.

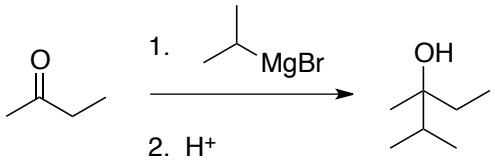
4. Hybridization
5. Impact of Electron Donors/Withdrawers
6. Amines/Ammoniums

Test 1 PS#3: Alcohol-related Mechanisms Problems

Organic Chemistry 2 Jasperse Test 1, Alcohol Chemistry

Draw Mechanisms for the Following Reactions

1.



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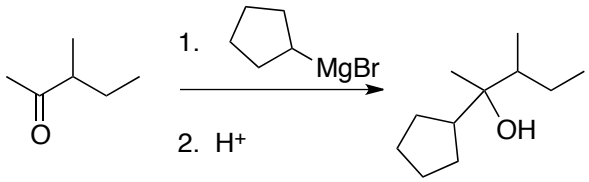

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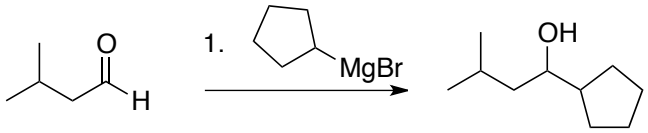

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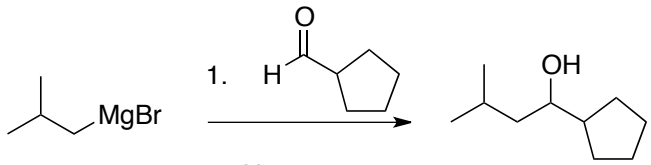

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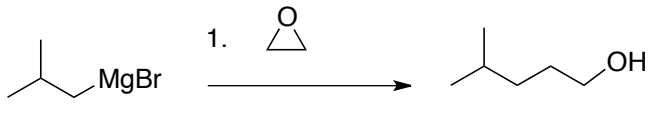
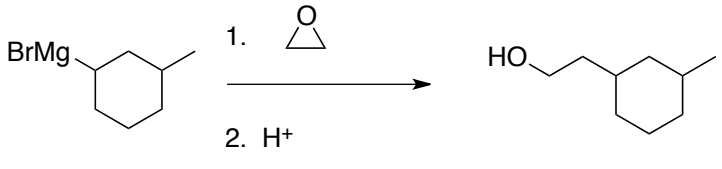
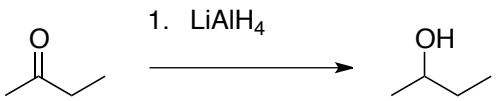
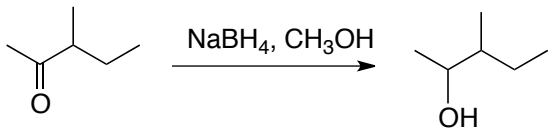
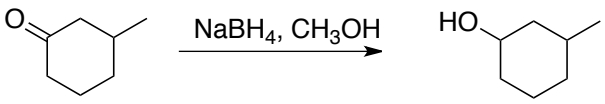


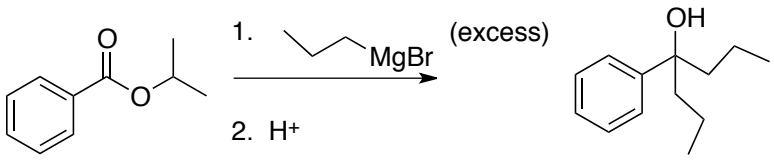
Test 1 PS#3: Alcohol-related Mechanisms Problems

6. 

7. 

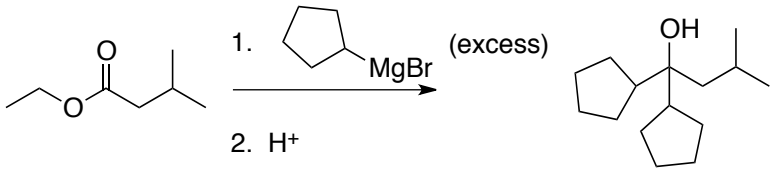
8. 

9. 

10. 

Test 1 PS#3: Alcohol-related Mechanisms Problems

11.



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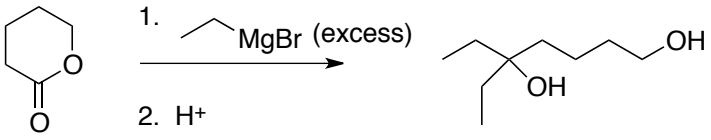

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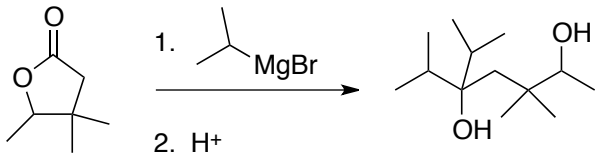

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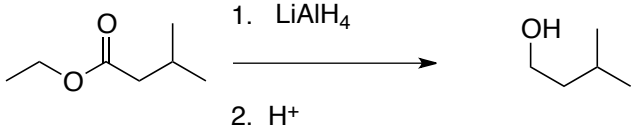
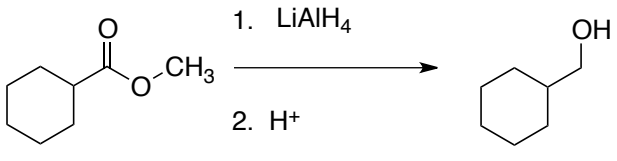
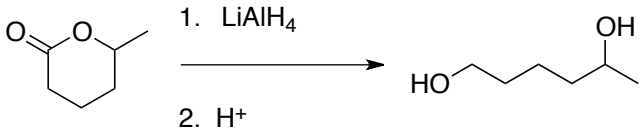


Test 1 PS#3: Alcohol-related Mechanisms Problems

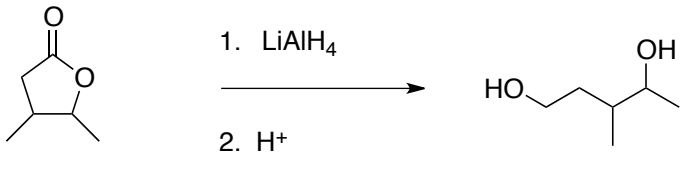
15.



16.



17.



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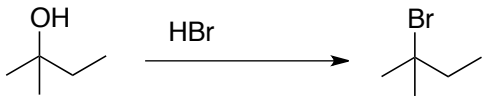

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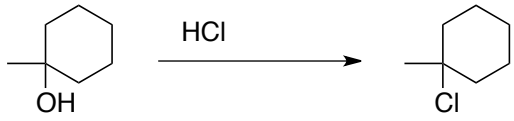

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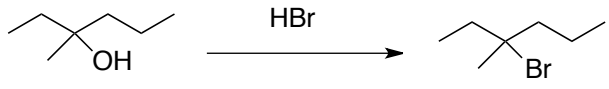
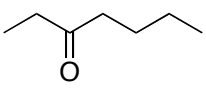
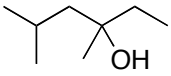
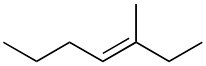


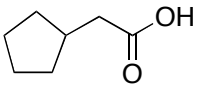
Test 1 PS#4: Retrosynthesis Problems

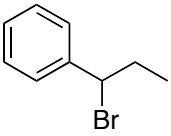
More Retrosynthesis Problems: One of the students asked if I could generate

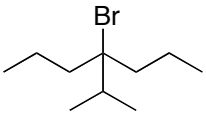
1. 

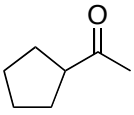
2. 

3. 

4. 

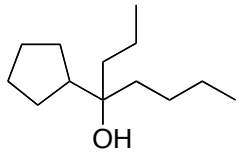
5. 

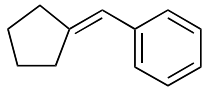
6. 

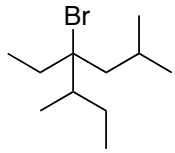
7. 

Test 1 PS#4: Retrosynthesis Problems

Harder Ones (more than one Grignard reaction required)

8. 

9. 

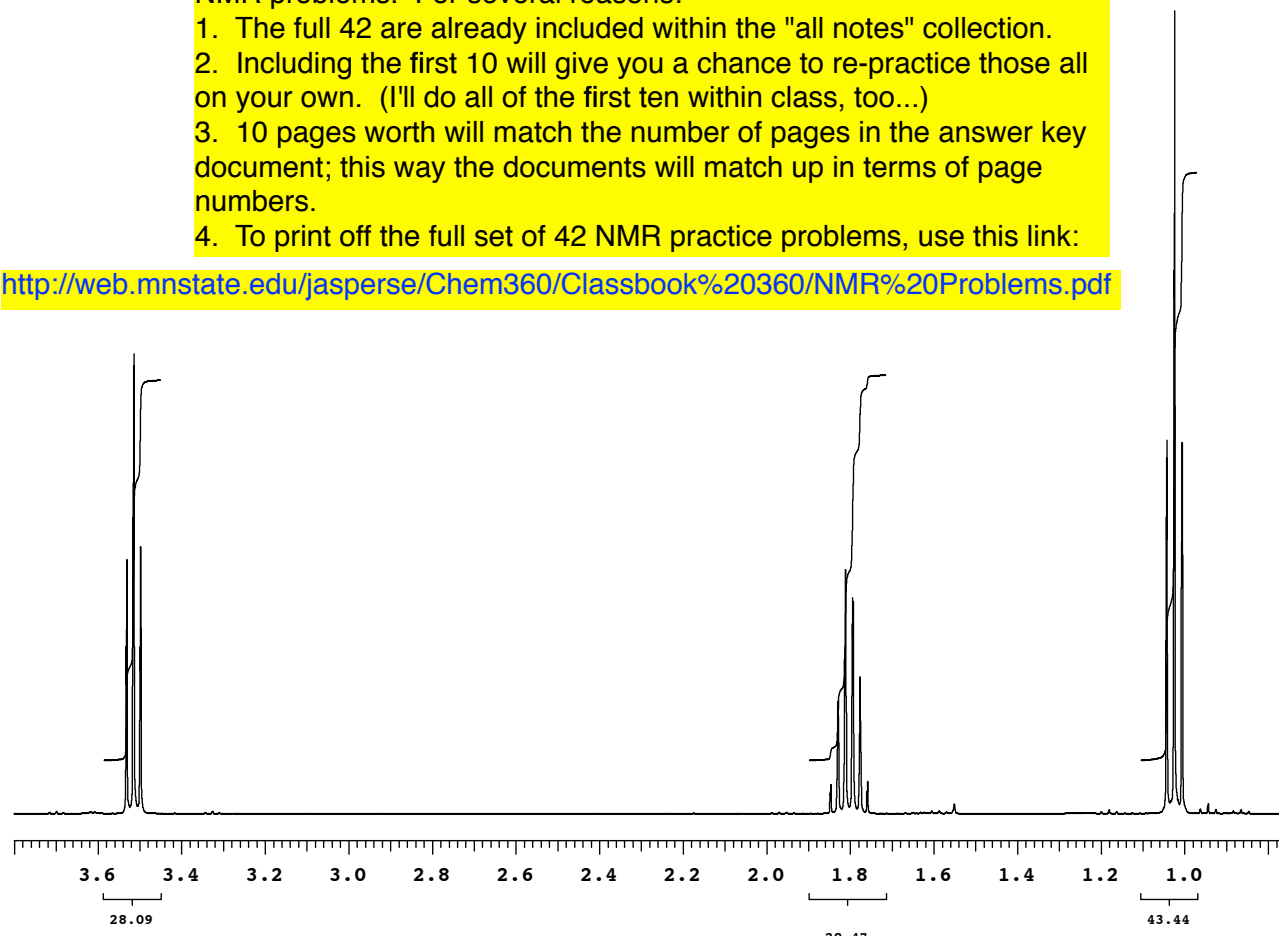
10. 

Jasperse Organic II NMR Problems

1. C_3H_7Cl

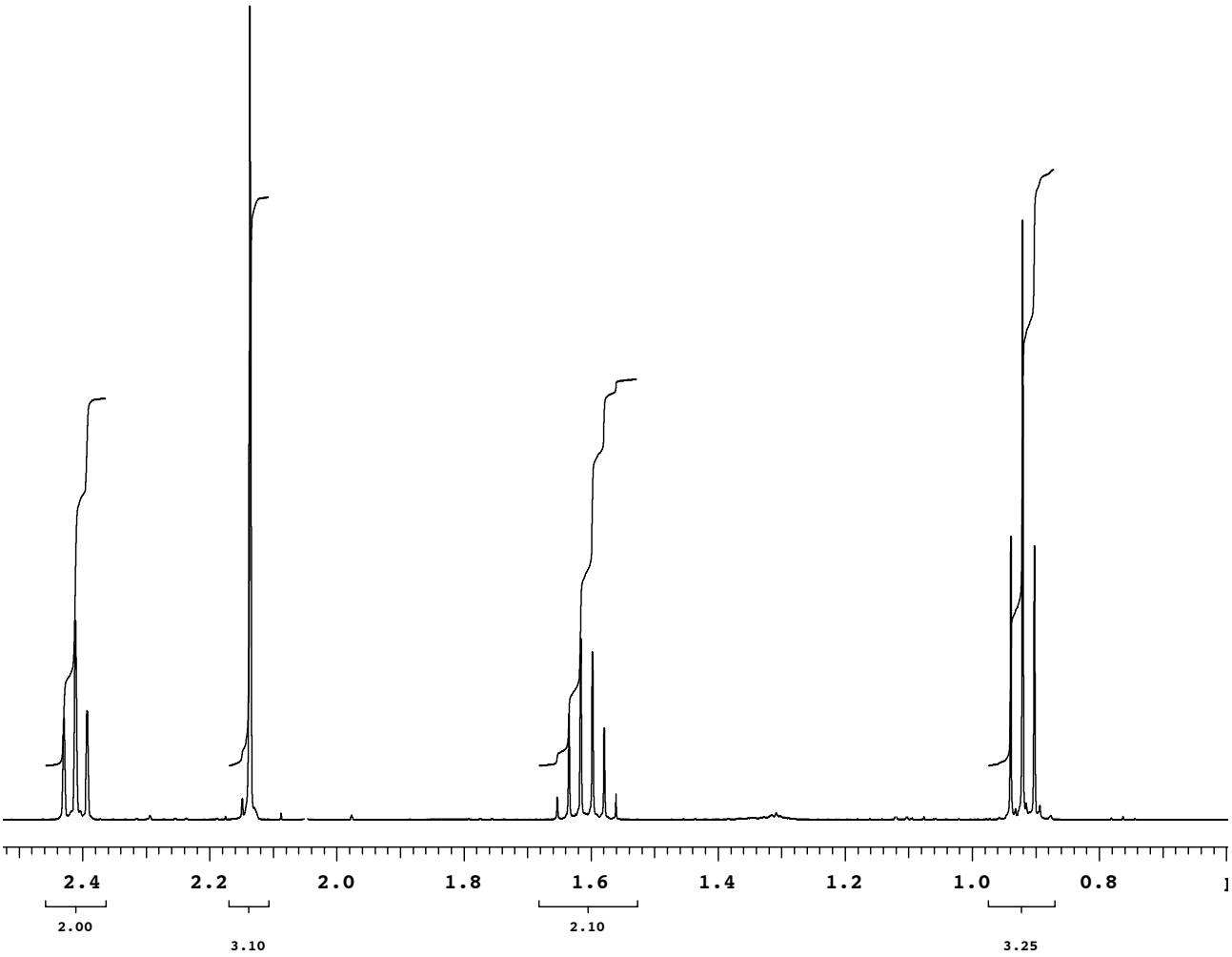
This practice-set collection includes only the first 10 or 42 practice NMR problems. For several reasons:
1. The full 42 are already included within the "all notes" collection.
2. Including the first 10 will give you a chance to re-practice those all on your own. (I'll do all of the first ten within class, too...)
3. 10 pages worth will match the number of pages in the answer key document; this way the documents will match up in terms of page numbers.
4. To print off the full set of 42 NMR practice problems, use this link:

http://web.mnstate.edu/jasperse/Chem360/Classbook%20360/NMR%20Problems.pdf



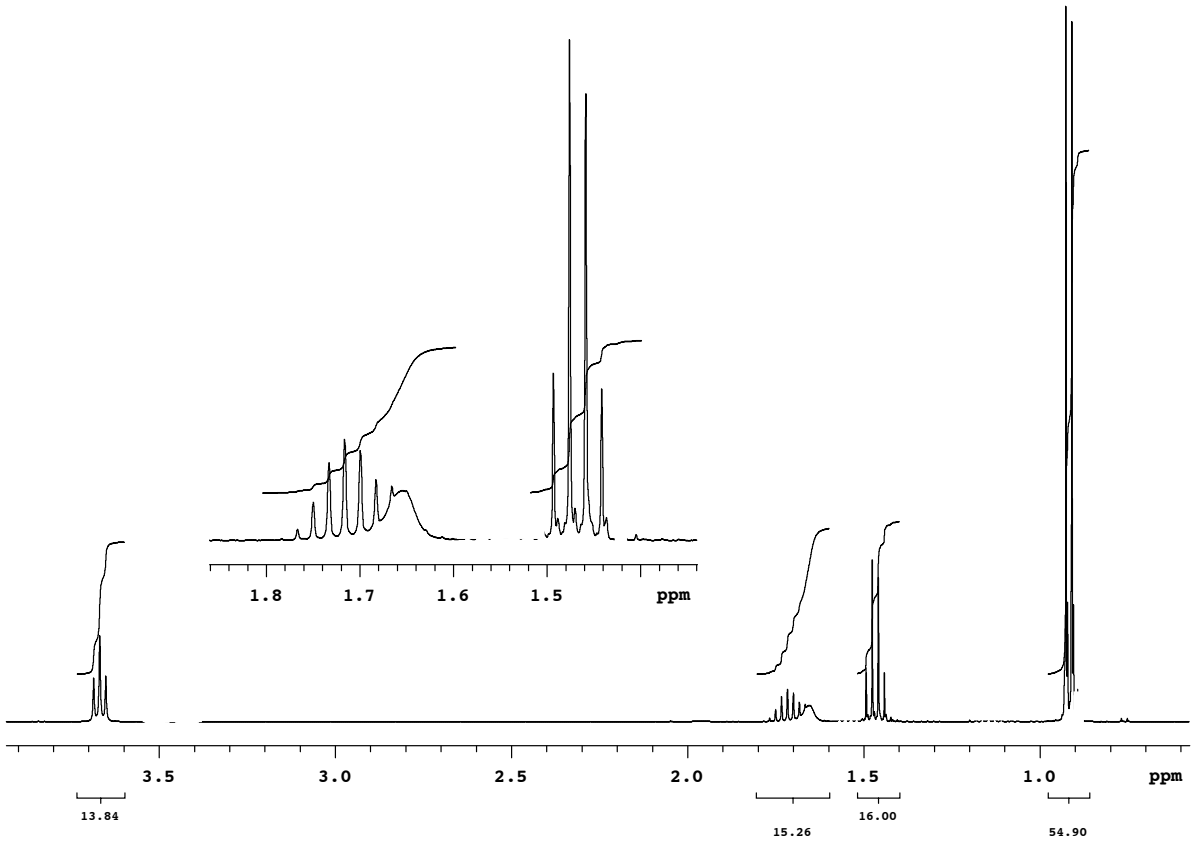
Test 2 NMR: Jasperse NMR Problems

2. $C_5H_{10}O$



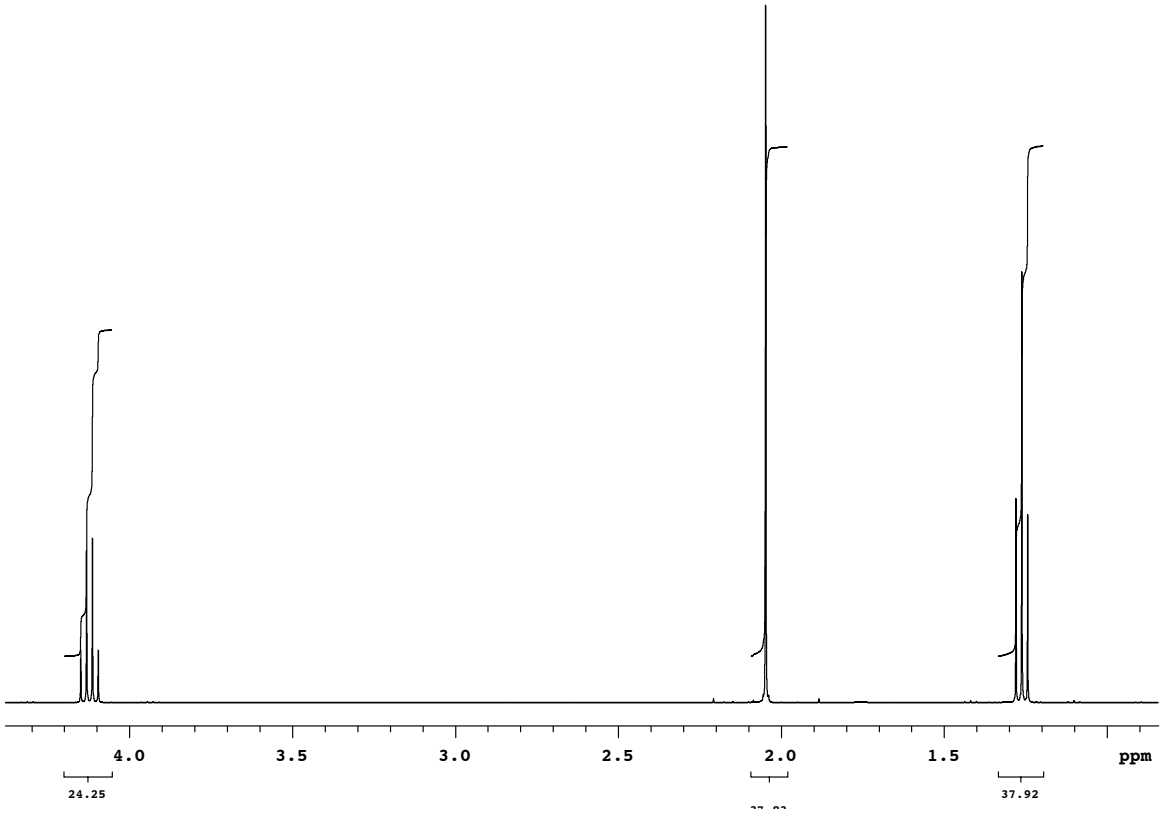
Test 2 NMR: Jasperse NMR Problems

3. $C_5H_{12}O$



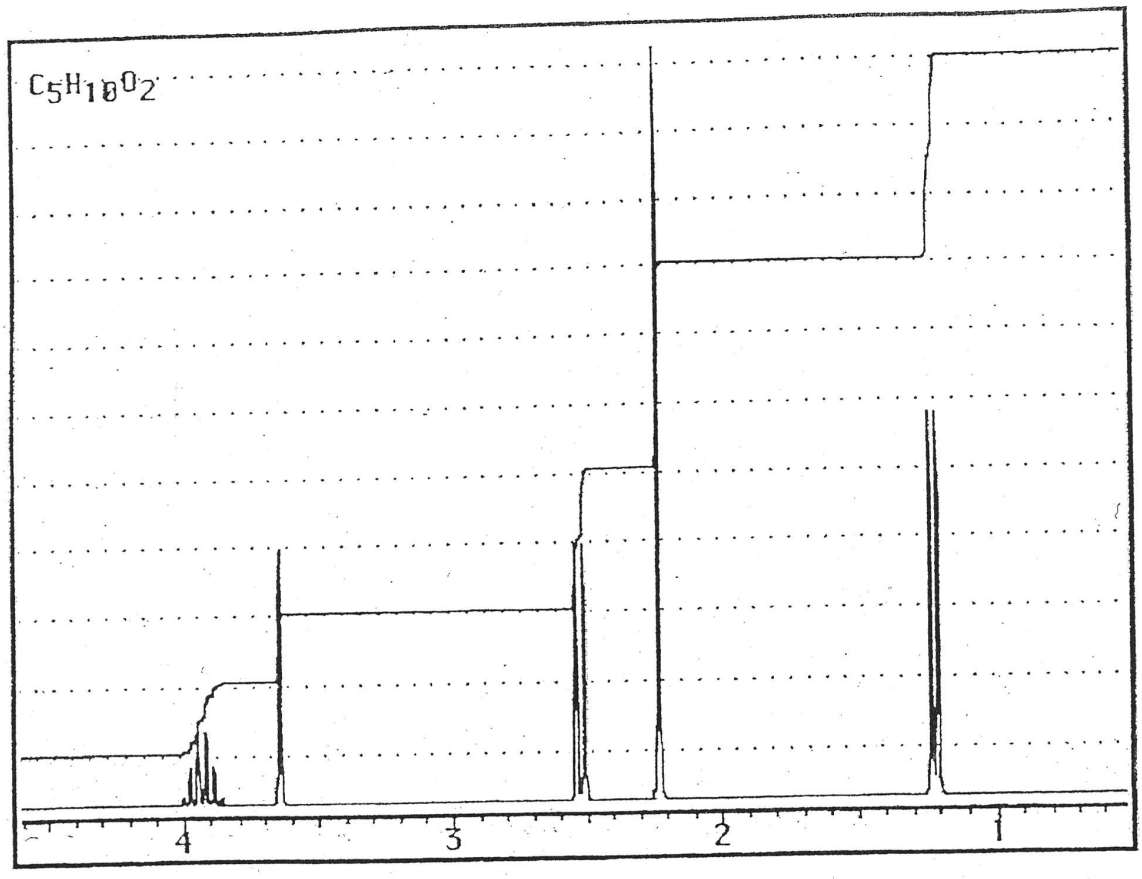
Test 2 NMR: Jasperse NMR Problems

4. $C_4H_8O_2$



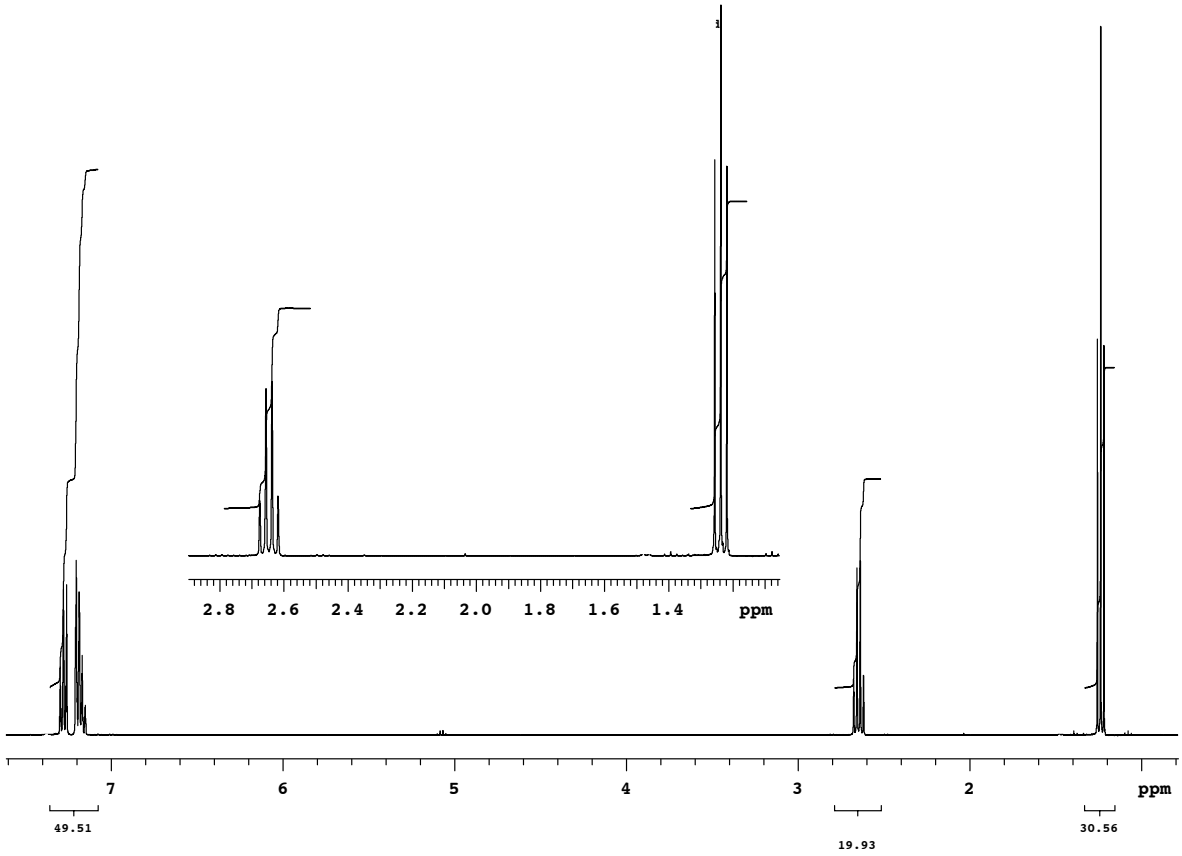
Test 2 NMR: Jasperse NMR Problems

5. $C_5H_{10}O_2$



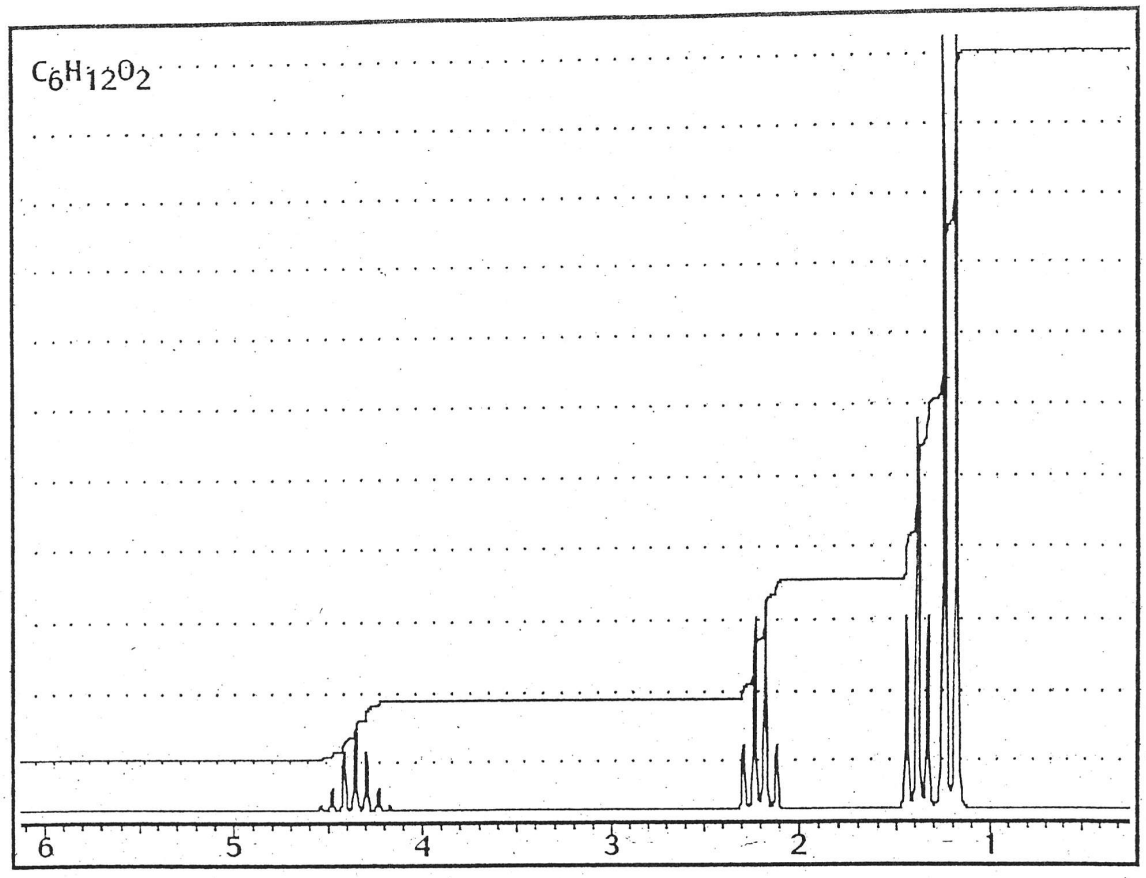
Test 2 NMR: Jasperse NMR Problems

6. C_8H_{10}



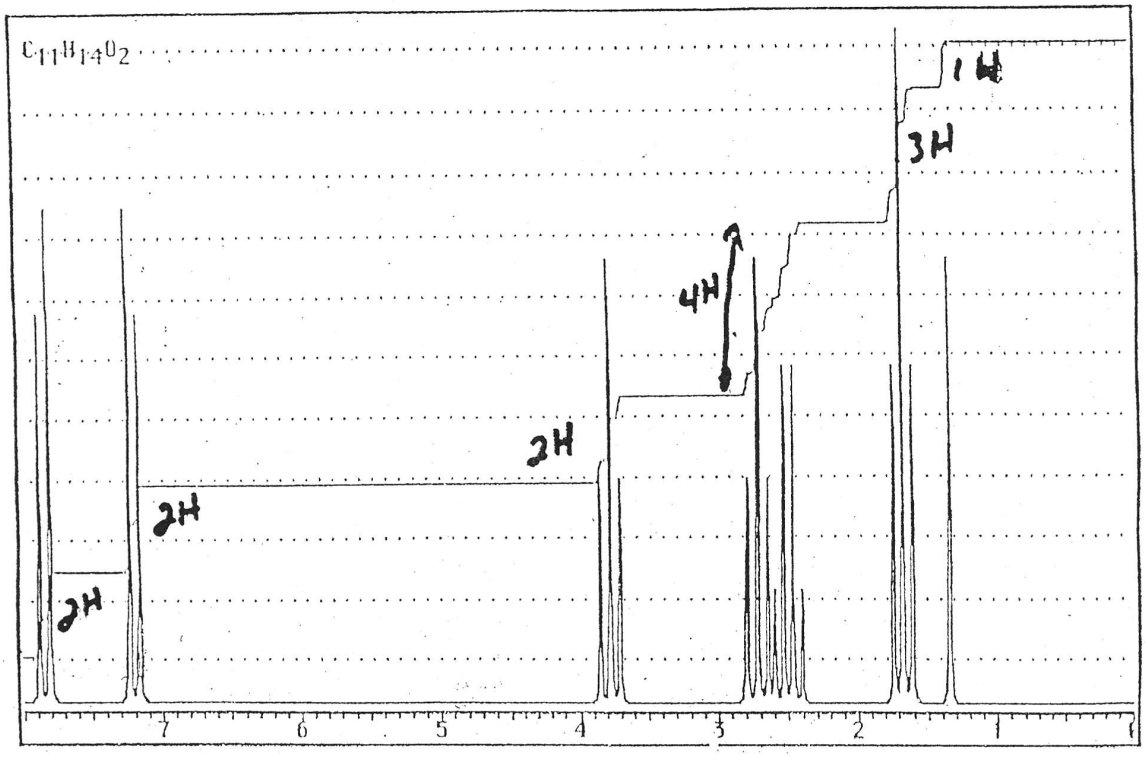
Test 2 NMR: Jasperse NMR Problems

7. $C_6H_{12}O_2$



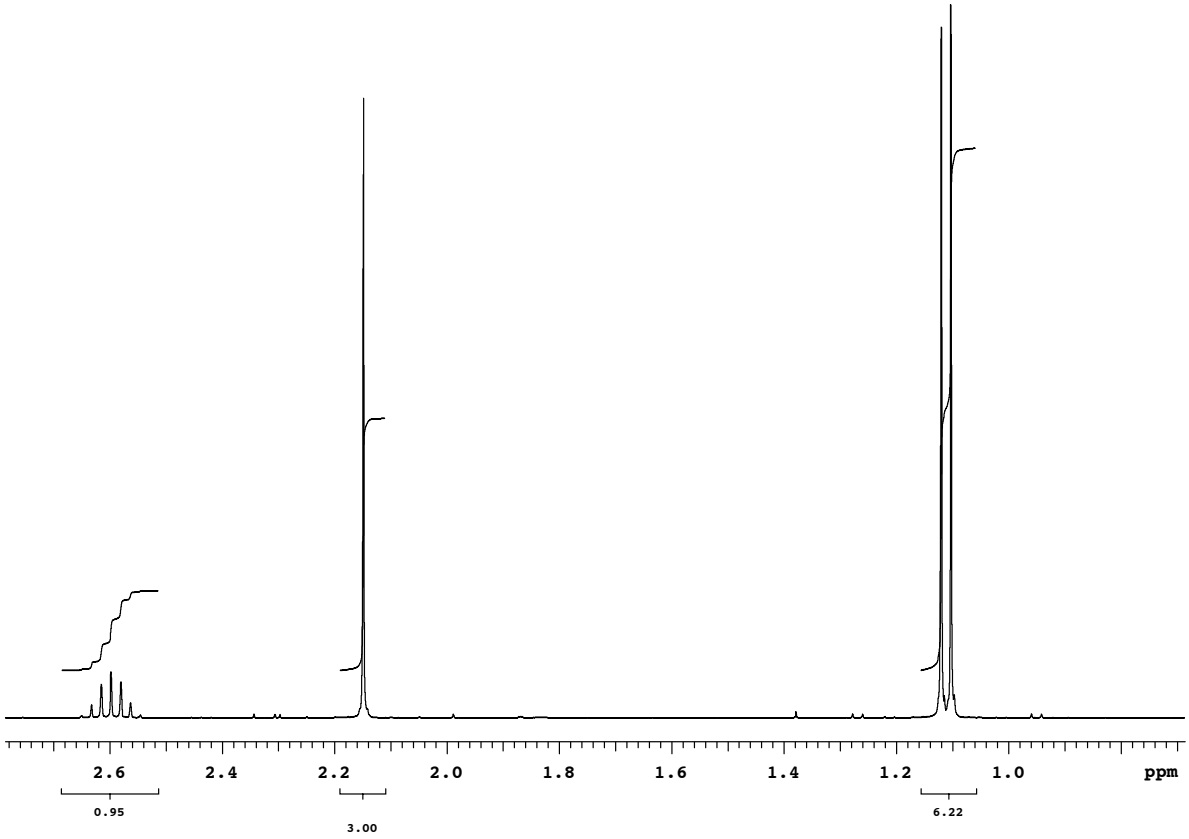
Test 2 NMR: Jasperse NMR Problems

8. $C_{11}H_{14}O_2$

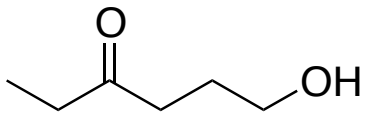


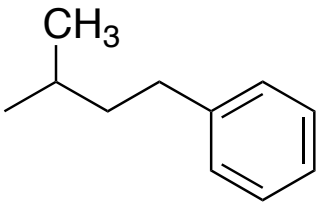
Test 2 NMR: Jasperse NMR Problems

9. $C_5H_{10}O$



10. Predict the Spectrum for: Test 2 NMR: Jasperse NMR Problems

a. 

b. 

c. Identify the Structure from the Shorthand NMR (nongraphic)

C_4H_8O

1.05, triplet, 3H
2.13, singlet, 3H
2.47, quartet, 2H

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2. Including the first 10 will give you a chance to re-practice those all on your own. (I'll do all of the first ten within class, too...)
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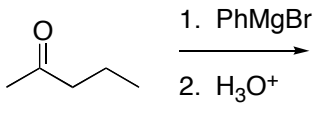
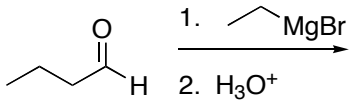
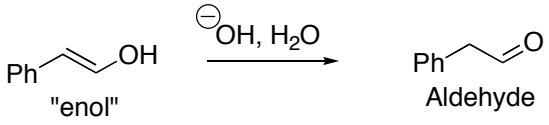
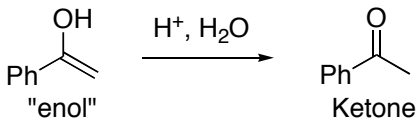
http://web.mnstate.edu/jasperse/Chem360/Classbook%20360/NMR%20Problems.pdf

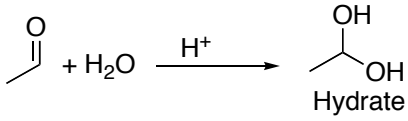
Some Practice Problems for the Carbonyls Test 3
Draw the Products and Mechanisms for the following Reactions

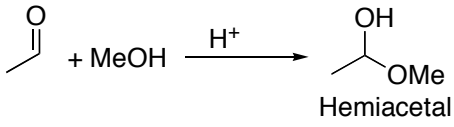
1. 

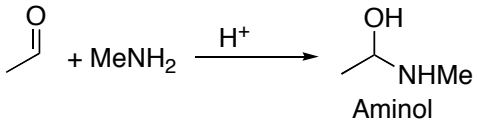
2. 

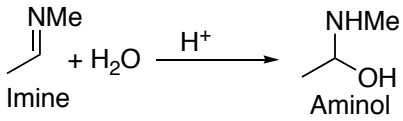
3. 

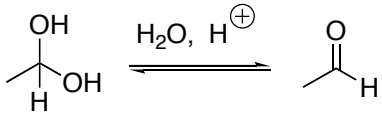
4. 

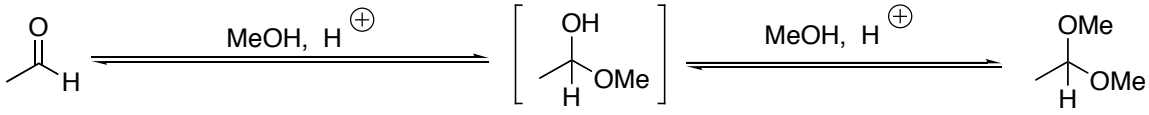
5. 

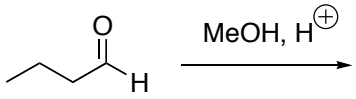
6. 

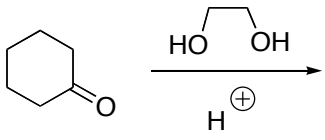
7. 
O
+ MeNH2
H+
OH
NHMe
Aminol

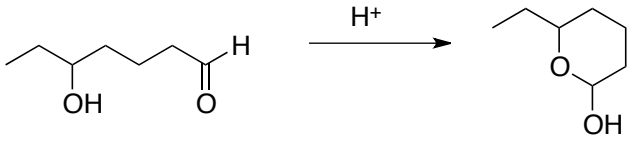
8. 
NMe
+ H2O
H+
Imine
NHMe
OH
Aminol

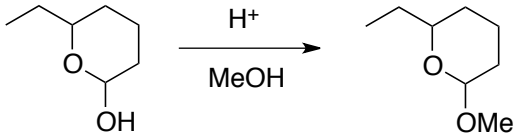
9. 
OH
OH
H
H2O, H
O
H

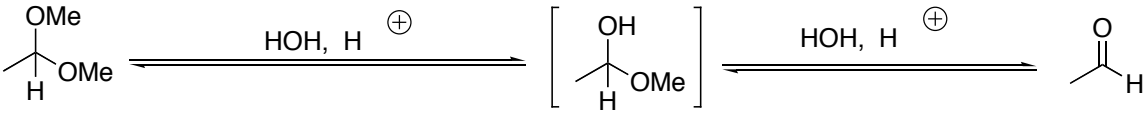
10. 
O
H
MeOH, H
OH
OMe
H
MeOH, H
OMe
OMe
H

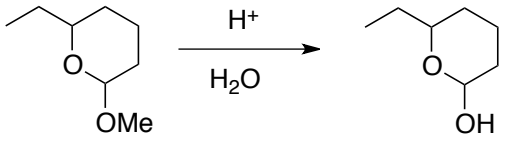
11. 
O
H
MeOH, H

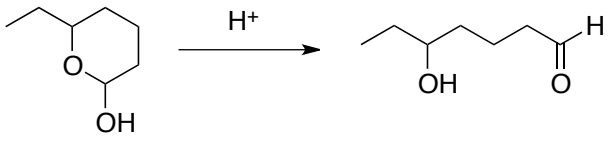
12. 
O
HO
OH
H

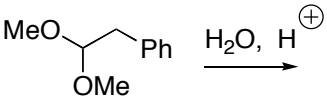
13. 

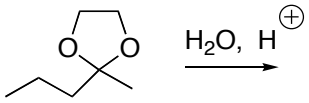
14. 

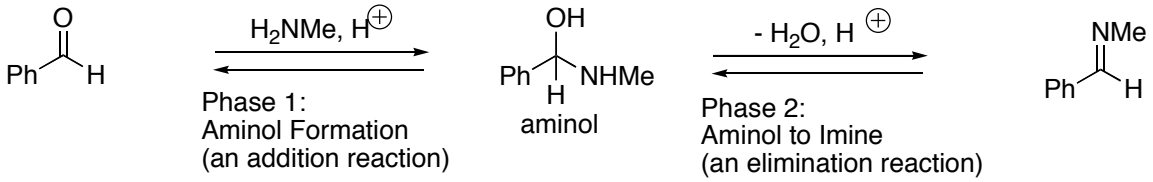
15. 

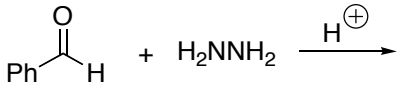
16. 

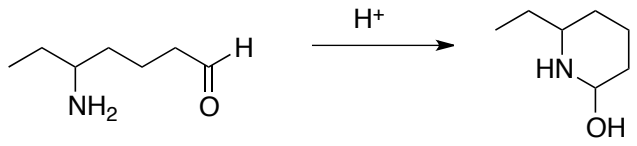
17. 

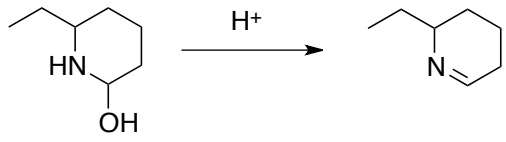
18. 

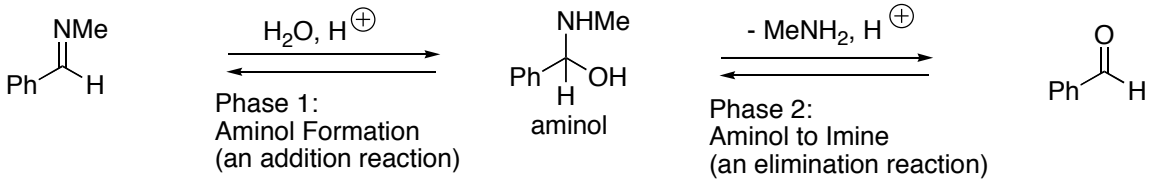
19. 

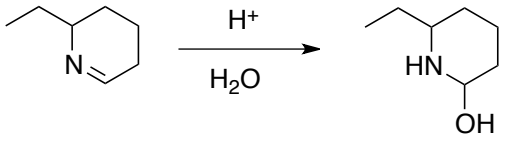
20. 

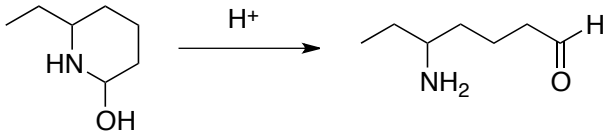
21. 

22. 

23. 

24. 

25. 

26. 

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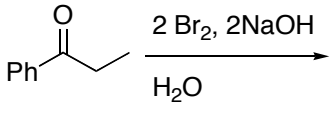
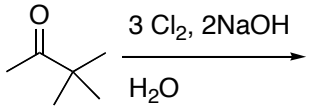
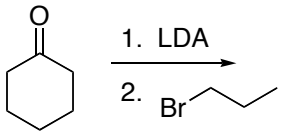
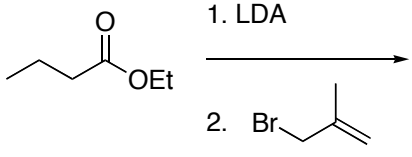
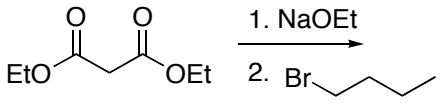
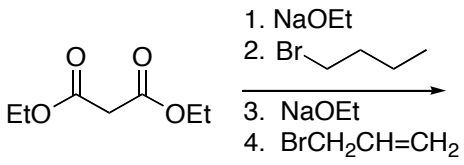
27. 

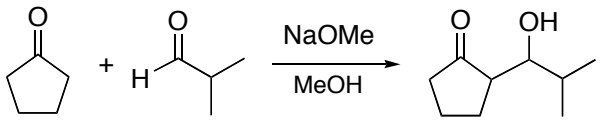
28. 

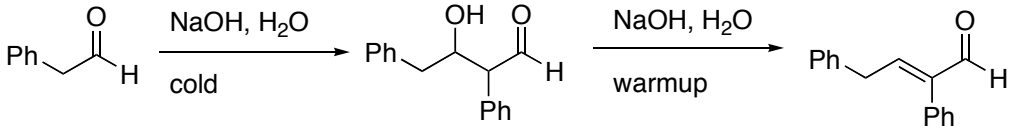
29. 

30. 

31. 

32. 

33. 

34. 

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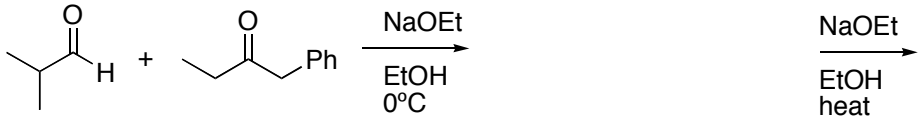
36. 

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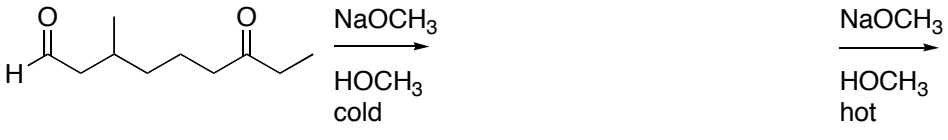
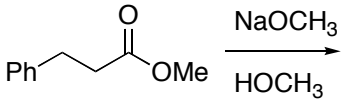
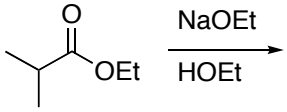
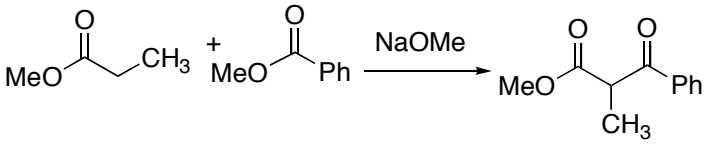
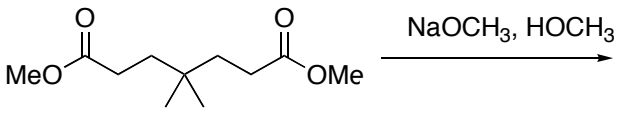
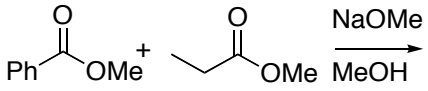
38. 

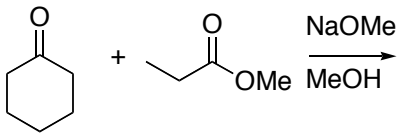
39. 

40. 

41. 

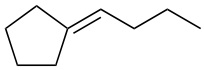
42. 

43. 

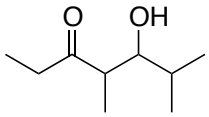
44. 

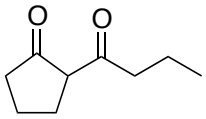
Some Practice Problems for the Carbonyls Test 3

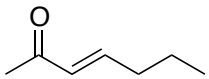
RETROSYNTHESIS PRACTICE: Design synthesis for the following, FROM ALCOHOLS WITH NO MORE THAN 5 CARBONS. YOU MAY ALSO USE ESTERS, or any inorganic agents (PPh_3, PBr_3, PCC, H_2CrO_4, etc.)

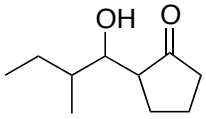
1. 

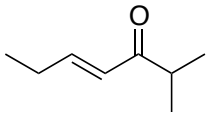
No other alkene structural isomers allowed (in other words, don't make an alcohol elimination reaction)

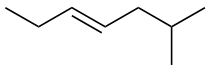
2. 

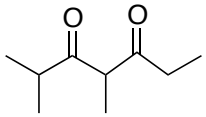
3. 

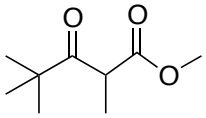
4. 

5. 

6. 

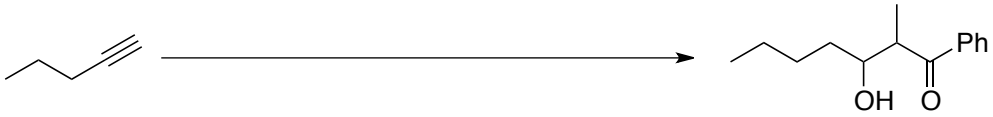
7. 

8. 

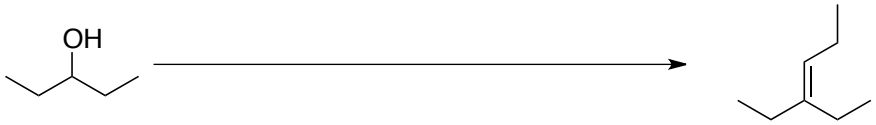
9. 

SYNTHESIS DESIGN PRACTICE: Provide Reagents for the Following Transformations. You may use anything you like, so long as you involve the starting chemical specified.

1. 

2. 

3. 

4. 

No other alkene isomers form

5. 

6. 

7. 

Organic Chemistry Jasperse Acid-Base Practice Problems

A. Identify each chemical as either an "acid" or a "base" in the following reactions, and identify "conjugate" relationships.

-You should have one acid and one base on each side

-You should have two conjugate pairs

1. $CH_3CH_2OH + NaOH \rightleftharpoons CH_3CH_2ONa + H_2O$

2. $CH_3CH_2NHLi + CH_3OH \rightleftharpoons CH_3CH_2NH_2 + CH_3OLi$

3. $CH_3CH_2CO_2H + CH_3MgBr \rightleftharpoons CH_3CH_2CO_2MgBr + CH_4$

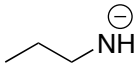
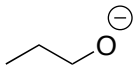
4. $CH_3OH + H_3O^+ \rightleftharpoons H_2O + CH_3OH_2^+$

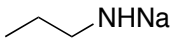
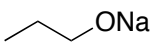
5. $CH_3CH_2NH_3^+ + CH_3OH \rightleftharpoons CH_3CH_2NH_2 + CH_3OH_2^+$

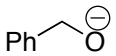
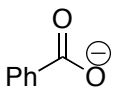
B. Choose the More **Basic** for Each of the Following Pairs (Single Variable). You can use stability to decide.

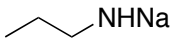
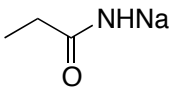
6. NH_3 $NaNH_2$

7. NaOH H_2O

8.  

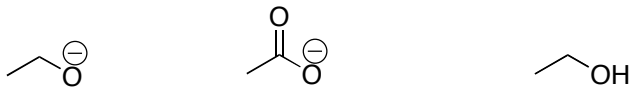
9.  

10.  

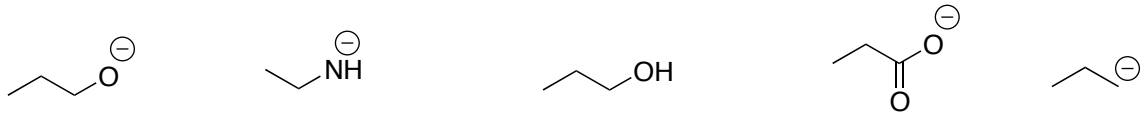
11.  

C. Rank the basicity of the following sets: Multiple Variable Problems

12. CH_3MgBr CH_3NHNa CH_3NH_2

13. 

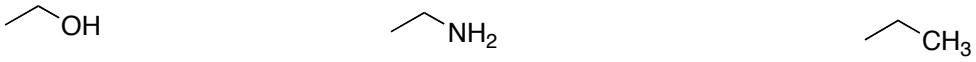
14. 

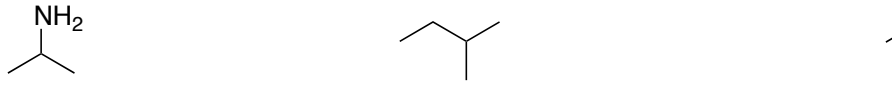
15. 

D. Choose the More Acidic for Each of the Following Pairs: Single Variable Problems

16. 

17. 

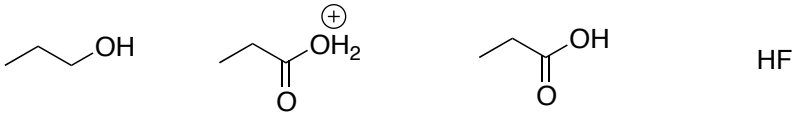
18. 

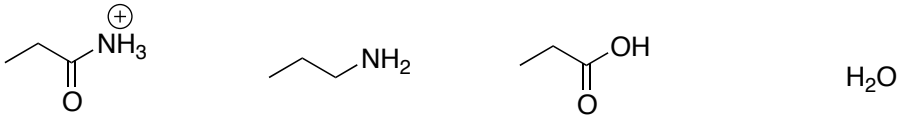
19. 

20. 

21. 

E. Rank the acidity of the following sets: Multiple Variable Problems

22. 

23. 

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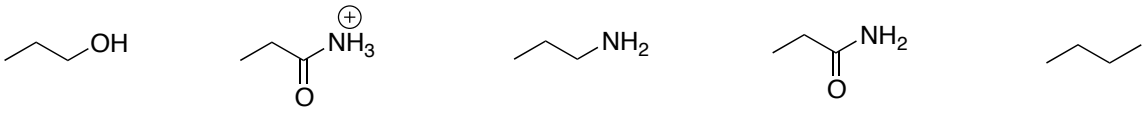
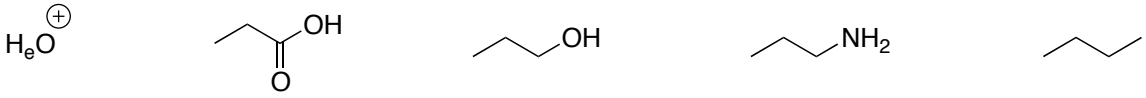
25. 

26. 

F. Draw arrow to show whether equilibrium favors products or reactants. (Why?)

27. 

28. 

G. For the following acid-base reaction,
   a. put a box around the weakest base in the reaction
   b. put a circle around the weakest acid
   c. draw an arrow to show whether the equilibrium goes to the right or left. (4pt)

29. 

Acid-Base Chemistry (Section 1.13-18)

Acidity/Basicity Table

Entry	Class	Structure	Ka	Acid Strength	Base	Base Strength
1	Strong Acids	H-Cl, H_2SO_4	10^2		$Cl^{\ominus}$, $HO-S(=O)(=O)-O^{\ominus}$	
2	Hydronium	H_3O^+, ROH^+ cationic	10^0		H_2O, HOR neutral	
3	Carboxylic Acid	R-C(=O)-OH	10^{-5}		R-C(=O)-$O^{\ominus}$	
4	Ammonium Ion (Charged)	$R_3N^{\oplus}H$ Charged, but only weakly acidic!	10^{-12}		R_3N Neutral, but basic!	
5	Water	HOH	10^{-16}		$HO^{\ominus}$	
6	Alcohol	ROH	10^{-17}		$RO^{\ominus}$	
7	Ketones and Aldehydes	C(=O)-α-H	10^{-20}		C(=O)-α-$^{\ominus}$	
8	Amine (N-H)	$(iPr)_2N$-H	10^{-33}		$(iPr)_2N^{\ominus}Li^{\oplus}$	
9	Alkane (C-H)	RCH_3	10^{-50}		$RCH_2^{\ominus}$	

Base Stability

Quick Checklist of Acid/Base Factors

1. Charge
2. **Electronegativity**
3. **Resonance/Conjugation**

1. Cations more acidic than neutrals; anions more basic than neutrals
2. Carbanions < nitrogen anions < oxyanione < halides in stability
3. resonance anions more stable than anions without resonance

- **When neutral acids are involved, it's best to draw the conjugate anionic bases, and then think from the anion stability side.**

- The above three factors will be needed this semester. The following three will also become important in Organic II.

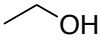
4. Hybridization
5. Impact of Electron Donors/Withdrawers
6. Amines/Ammoniums

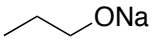
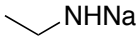
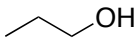
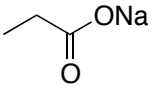
Test 4 PS#2: Acid-Base Practice (Less Easy)

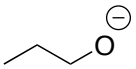
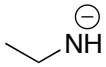
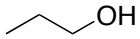
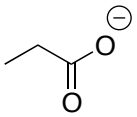
Organic Chemistry II Jasperse Acid-Base Practice Problems

A. Rank the basicity of the following sets: Multiple Variable Problems

1. CH_3MgBr CH_3NHNa CH_3NH_2 $(CH_3)_2NH$

2.    CH_3NH_2

3.    

4.     

5. CH_3NHNa $CH_3C(O)NH_2$ $(CH_3)_3N$ pyridine

6. $(CH_3)_3N$ pyridine CH_3NH_2 water

7. $(CH_3)_3N$ $PhCO_2Na$ CH_3NH_2 $PhCH_2ONa$ water

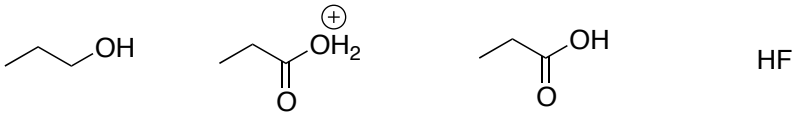
8. $(CH_3)_3N$ 4-methylaniline aniline pyrrole

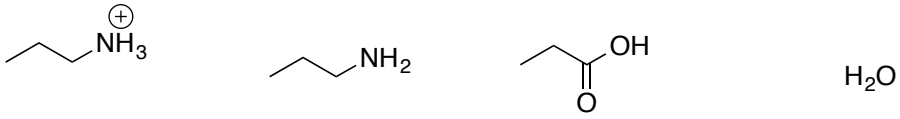
9. methylamine 4-ethanoylaniline aniline pyridine

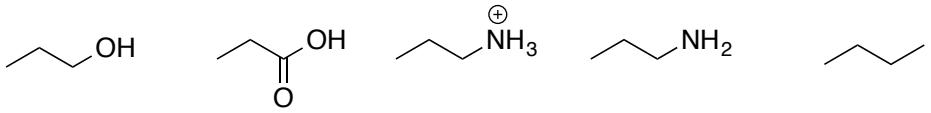
10. CH_3NH_2 CH_3CH_2ONa $PhCO_2Na$ methanol

Test 4 PS#2: Acid-Base Practice (Less Easy)

B. Rank the acidity of the following sets: Multiple Variable Problems

11. 

12. 

13. 

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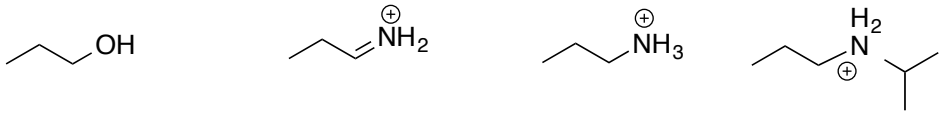
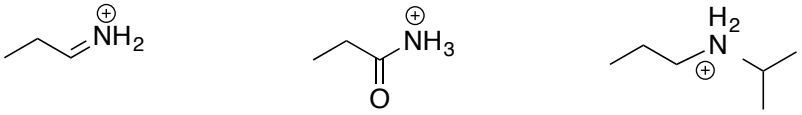
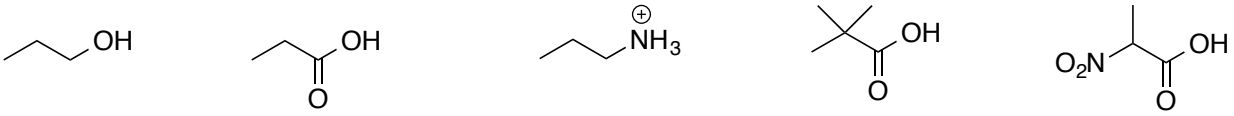
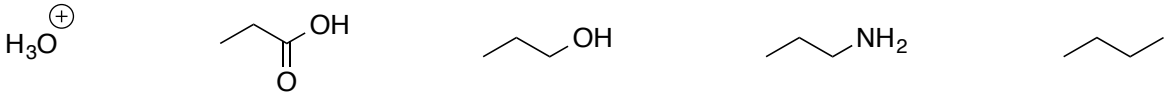
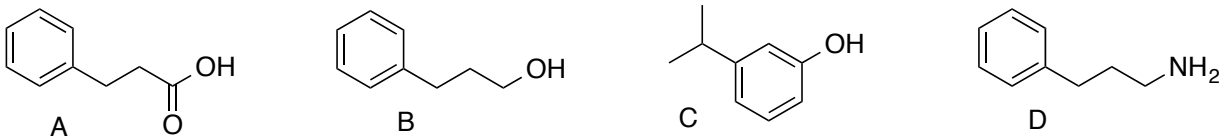
15. 

16. 

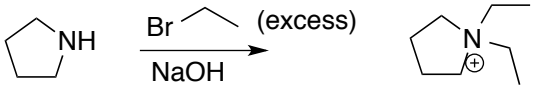
17. 

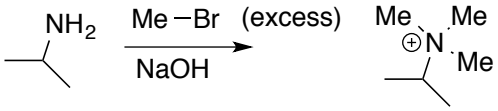
18. 

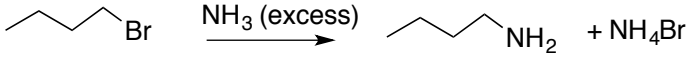
19. For the following structures:
    a. Which will extract from ether into neutral water?
    b. Which will extract from ether into basic (NaOH) water?
    c. Which will extract from ether into acid (HCl) water?

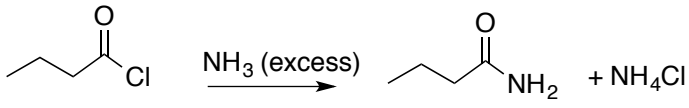


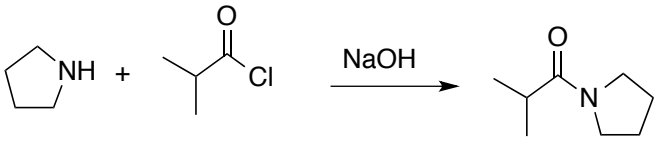
Some Practice Problems for the Amines/Acids Test 4
Draw the Mechanisms for the following Reactions
Page 4 has some synthesis-design practice problems.

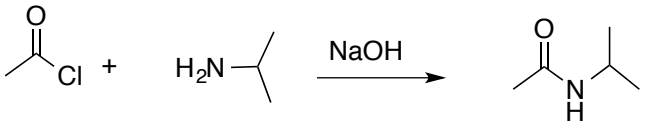
1. 

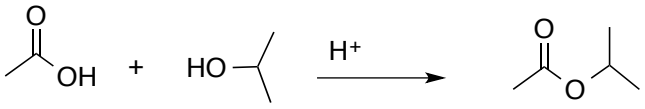
2. 

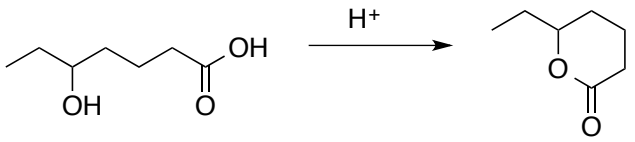
3. 

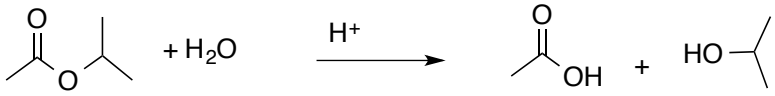
4. 

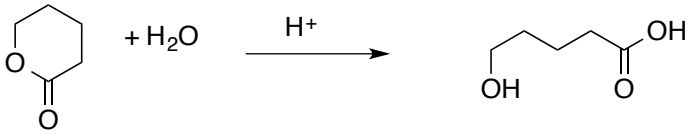
5. 

6. 
O
Cl
+
H2N
NaOH
O
N
H

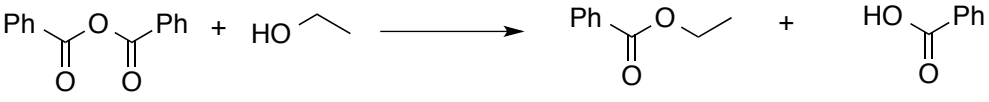
7. 
O
OH
+
HO
H+
O
O

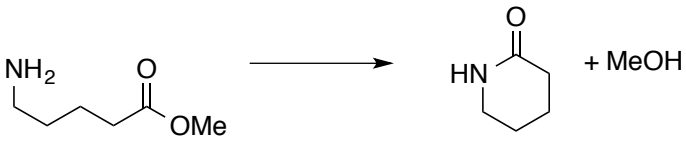
8. 
OH
OH
O
H+
O
O

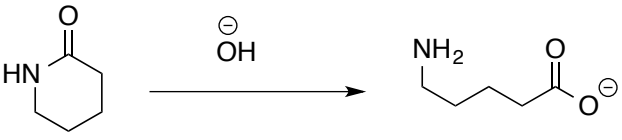
9. 
O
O
+ H2O
H+
O
OH
+
HO

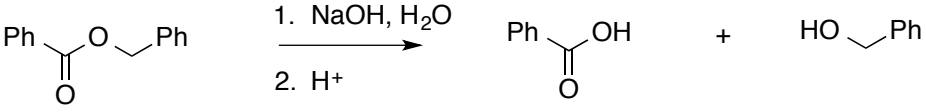
10. 
O
O
+ H2O
H+
OH
OH
O

11. 
Ph
Cl
O
+ H_2O
Ph
OH
O

12. 
Ph
O
O
Ph
+
HO
Ph
O
O
+
HO
Ph
O

13. 
NH_2
O
OMe
O
HN
+ MeOH

14. 
O
HN
$\ominus$
OH
NH_2
O
O$^{\ominus}$

15. 
Ph
O
O
Ph
1. NaOH, H_2O
2. H^+
Ph
OH
O
+
HO
Ph

Design Syntheses for the following transformations

16. 

17. 

18. 

19. 

20. 

21. 

22.