

Name: _____
 Last First MI

Chemistry 233-001 Exam 3

Spring 2017

Dr. J. Osbourn

Instructions: The first 12 questions of this exam should be answered on the provided Scantron. You must use a pencil for filling in the Scantron sheet. Ensure all erasures are complete. Any questions left blank will be marked incorrect. Any question with multiple answers selected will be marked incorrect. Answer the remaining questions on the exam itself. Show all work and provide complete explanations.

Please write your name on:

- **The first page (Exam Cover Page)**
- **The second page (Grading Page)**
- **The Scantron Sheet – Circle your Last Name**

Please bubble in your WVU Student ID Number on your Scantron sheet.

Fall 2017 Note: **Highlighted Questions** do not pertain to exam 3 material.

The Periodic Table

1 IA											18 VIII A						
1 H 1.01											2 He 4.00						
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 Al 26.98	4 Si 28.09	5 P 30.97	6 S 32.07	7 Cl 35.45	8 Ar 39.95										
19 K 39.1	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	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 127.6	53 I 126.9	54 Xe 131.29
55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac^ (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
*	90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)
^														

****Please do not rip off this exam cover page****

Name: _____
Last First MI

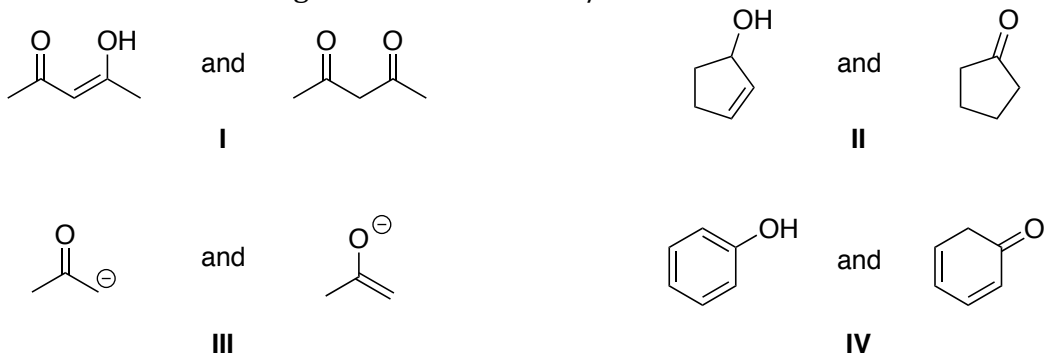
Grading Page: Exam 3

Page	Points Possible	Points Earned
Multiple Choice (3-5)	24	
6	18	
7	23	
8	20	
9	15 + 2	
TOTAL	100	

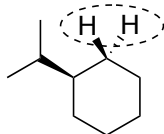
Multiple-Choice

Choose the one best answer for each of the following questions. Record each answer on the provided Scantron sheet. (2 points each)

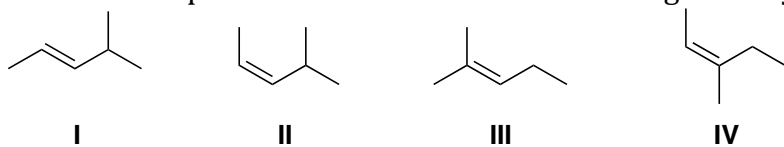
1. Which of the following are considered keto/enol tautomers?



- a. I only
b. I and IV
c. II only
d. I, II, and IV
e. I, II, III, and IV
2. The indicated protons in the molecule below are:

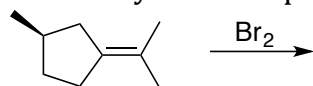


- a. Heterotopic
b. Homotopic
c. Enantiotopic
d. Diastereotopic
3. Rank the compounds below in order of increasing stability.



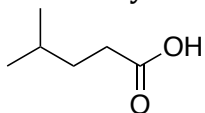
- a. I < II < IV < III
b. II < I < III ≈ IV
c. II < I < III < IV
d. II < III < IV < I
e. III ≈ IV < I < II
4. Which one of the following statements is false?
- a. Increasing substitution stabilizes a carbocation by hyperconjugation.
b. The boron in BH₃ has an empty p-orbital.
c. The rate-determining step in HX addition to an alkene is carbocation formation.
d. Alkynes are more reactive toward HX addition than alkenes.
e. None of the above statements are false.

5. How many different products result from the following reaction?



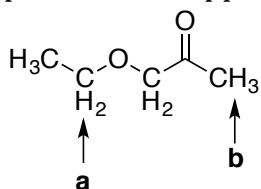
- a. 1 product
- b. 2 products – a pair of enantiomers
- c. 2 products – a pair of diastereomers
- d. 4 products – two pairs of enantiomers

6. How many chemically distinct types of hydrogen are in the molecule below?



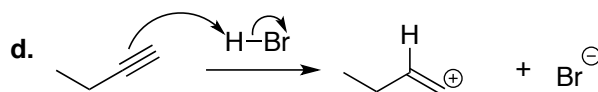
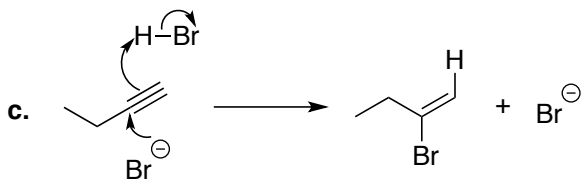
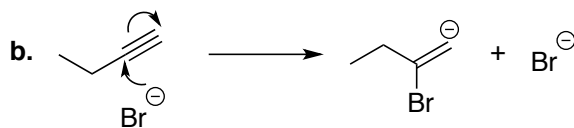
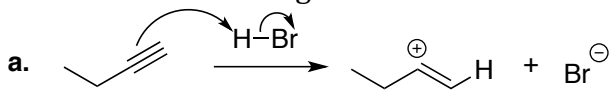
- a. 2
- b. 4
- c. 5
- d. 6
- e. 8

7. In the ^1H NMR spectrum of the compound shown below, proton **a** will appear as a _____ and proton **b** will appear as a _____.

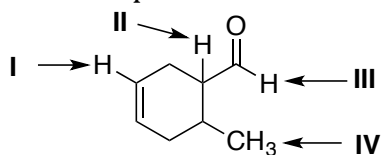


- a. doublet, triplet
- b. quartet, singlet
- c. sextet, triplet
- d. quartet, triplet
- e. singlet, singlet

8. Which of the following best describes the first step of the mechanism of H-Br addition to 1-butyne?

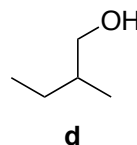
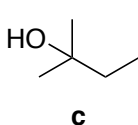
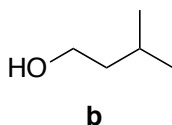
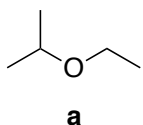
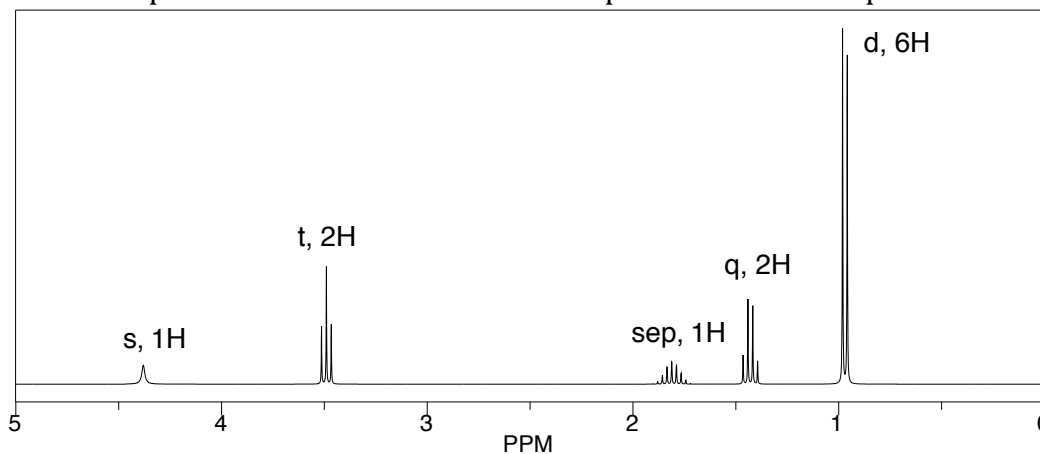


9. Rank the protons shown below in order of increasing chemical shift in ^1H NMR.



- $\text{IV} < \text{II} < \text{I} < \text{III}$
- $\text{IV} < \text{II} < \text{III} < \text{I}$
- $\text{II} < \text{IV} < \text{I} < \text{III}$
- $\text{I} < \text{IV} < \text{III} < \text{II}$
- $\text{III} < \text{II} < \text{IV} < \text{I}$

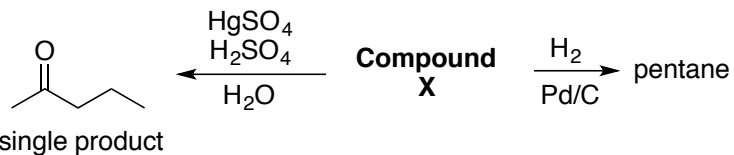
10. Which compound shown below matches the provided ^1H NMR spectrum?



11. In the ^1H NMR spectrum of 1-bromobutane, the most deshielded hydrogens are those bound to

- C1
- C2
- C3
- C4

12. Which choice below best describes the structure of compound X?

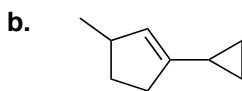
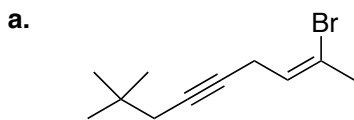


- 2-butyne
- 2-pentyne
- 1-pentyne
- 2-pentene
- 1-butyne

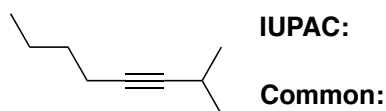
Completion Section

Answer the remaining questions in the spaces provided.

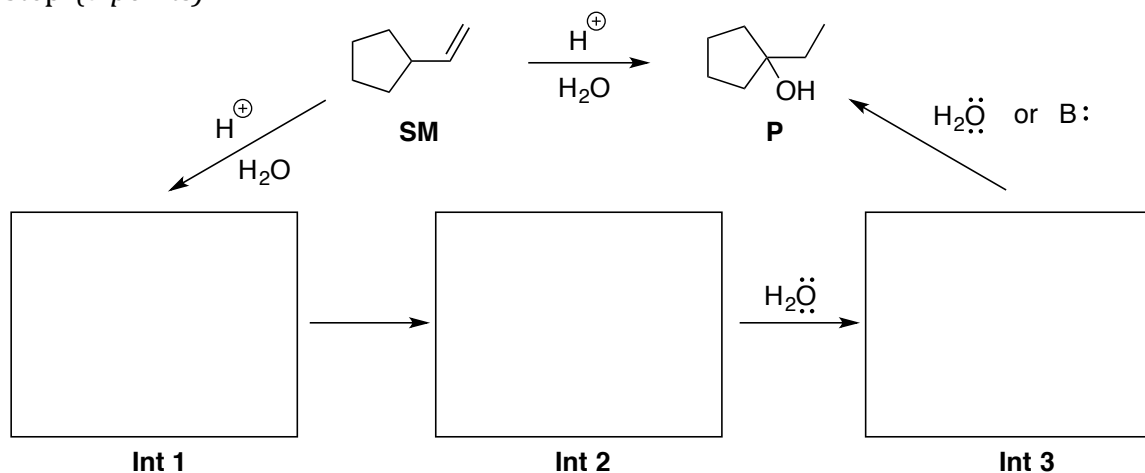
13. Provide the IUPAC name for each compound below including *E/Z* where appropriate. (2 pts each)



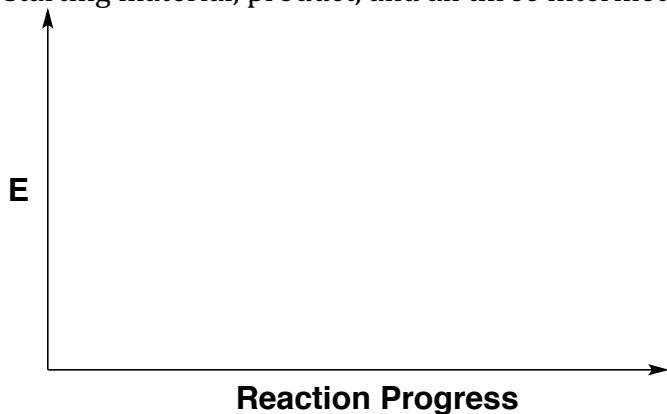
14. Provide both the IUPAC and common name for the compound shown below. (2 points)



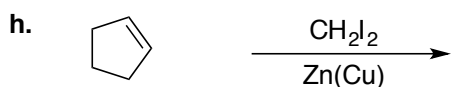
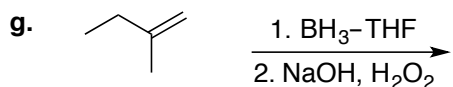
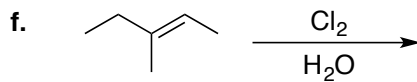
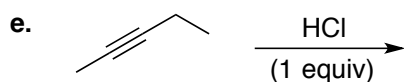
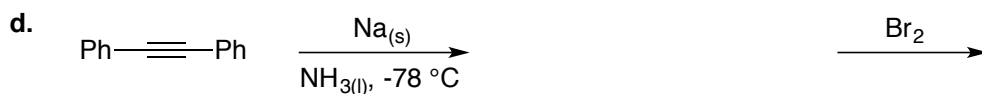
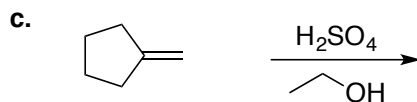
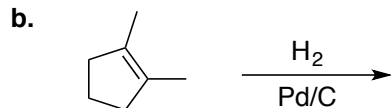
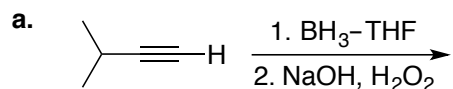
15. Complete the electron pushing mechanism for the reaction shown below by drawing in the intermediates in the boxes provided, **and** by adding curved arrows to show electron flow in every step. (7 points)



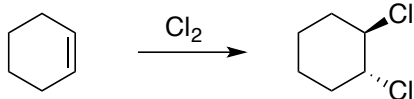
16. Draw an energy diagram for the reaction shown in question 15. Clearly indicate the locations of the starting material, product, and all three intermediates. (5 points)



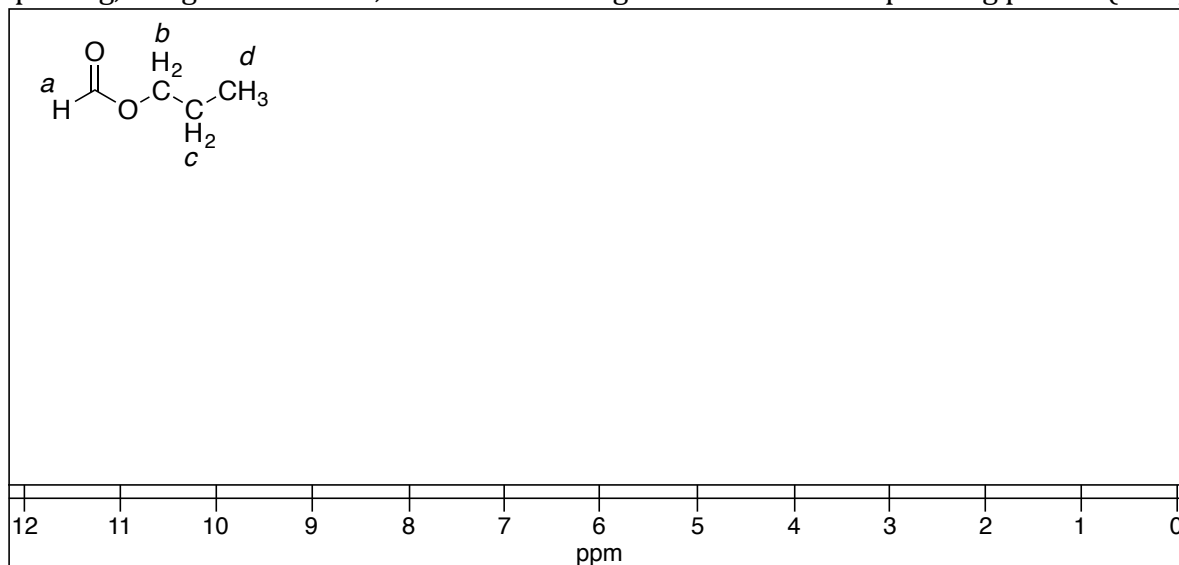
17. Predict the major organic product(s) for each reaction shown below. Show stereochemistry where appropriate. If enantiomers are formed, you only need to draw one enantiomer. (2 points each)



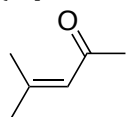
18. Show the complete electron pushing mechanism for the reaction below. Draw all relevant intermediates and use curved arrows to show electron flow. (5 points)



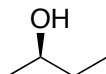
19. Draw a representative ^1H NMR spectrum for the compound shown below. Be sure to show correct splitting, integration values, and label each signal with the corresponding proton (i.e. a). (6 points)



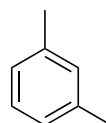
20. For each compound shown below, determine the number of chemically distinct types of hydrogen. (2 points each)



_____ distinct H

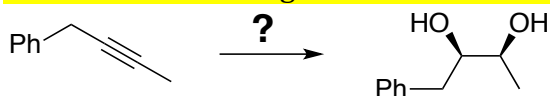


_____ distinct H



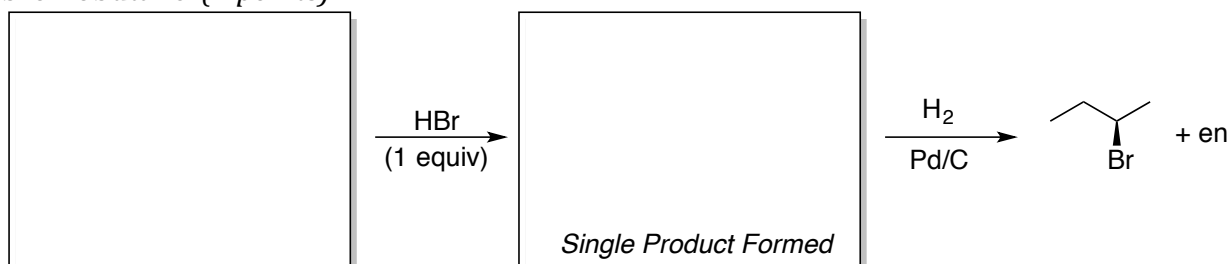
_____ distinct H

21. **Synthesis:** Show the sequence of reactions that you would need to carry out in order to transform the indicated starting material into the desired product. (4 points)

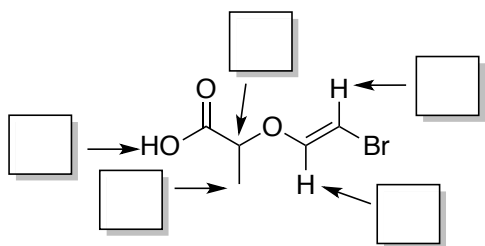


Fall 17: We didn't cover the reagent you need for the last step (OsO_4).

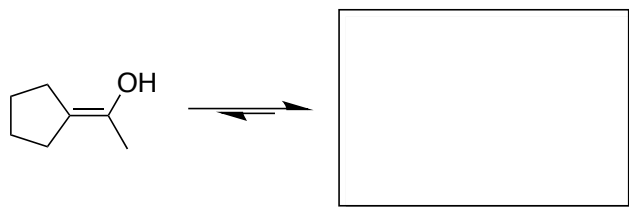
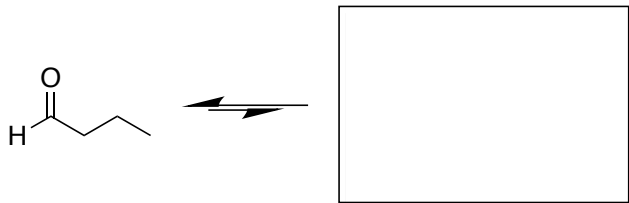
22. Fill in the boxes with the compounds that will undergo the following transformations to give 2-bromobutane. (4 points)



23. Predict the expected ^1H NMR splitting (s, d, t, q, quin, sex, or sep) for each hydrogen in the molecule shown below. (5 points)

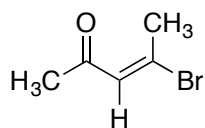


24. Draw the tautomer of each molecule shown below. (2 points each)

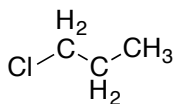


25. In each compound shown below, circle the specified proton type. (2 points each)

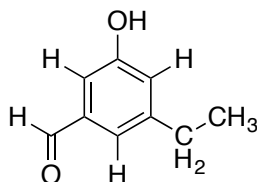
most deshielded proton:



most shielded proton:



most upfield proton:



26. **Bonus:** The following molecule was prepared by chlorination of an alkene followed by an intramolecular cyclization reaction. What was the starting material used for the reaction? (2 pts)

