

# CHEM 3311 (Richardson) Final Exam – Dec. 18, 2017

Your Name: \_\_\_\_\_

Student ID: \_\_\_\_\_

- Recitation (check one)      O 1:00 Mon (Zhenhao Chen)  
 O 8:00 Tue (Rachel Weintraub)      O 11:00 Tue (Patrick Li)  
 O 2:00 Tue (Zhenhao Chen)      O 1:00 Wed (Zepeng Lei)  
 O 3:00 Wed (Rachel Weintraub)      O 9:00 Thu (Rachel Weintraub)  
 O 12:00 Thu (Patrick Li)      O 3:00 Thu (Zepeng Lei)  
 O 2:00 Fri (Rachel Weintraub)      O 3:00 Fri (Rachel Weintraub)

Question	Score	Out of
1		20
2		20
3		45
4		20
5		20
6		40
7		20
8		15
9		15 e.c.
<b>Total</b>		<b>200</b>

This is a closed-book exam. The use of notes, calculators, or cell phones will not be allowed during the exam. You may use models sets brought in a clear ziplock bag. Use the backs of the pages for scratch work. If your final answer is not clearly specified, you will lose points. For mechanisms, show all intermediates including correct formal charges, but do not show transition states.

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																				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																				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		
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *																			thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]		
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *	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					unnilium 110 Uun [271]	ununium 111 Uuu [272]	ununbium 112 Uub [277]					
			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]					ununquadium 114 Uuq [289]							

\* Lanthanide series

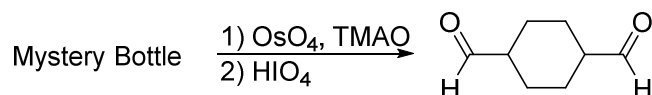
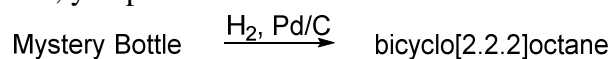
\*\* Actinide series

## pKa Values

HI	-10	CH <sub>3</sub> COOH	4.7	ArOH	10	H <sub>2</sub>	35
HBr	-8	HN <sub>3</sub>	4.7	RSH	10-12	NH <sub>3</sub>	36
HCl	-6	H <sub>2</sub> S	7.0	H <sub>2</sub> O	15.7	H <sub>2</sub> C=CH <sub>2</sub>	45
H <sub>3</sub> O <sup>+</sup>	-1.7	NH <sub>4</sub> <sup>+</sup>	9.3	ROH (R=alkyl)	16-18	CH <sub>4</sub>	60
HF	3.2	HCN	9.4	HC≡CH	26		

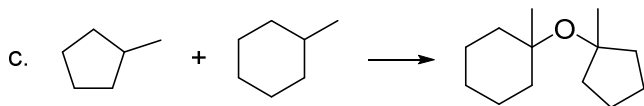
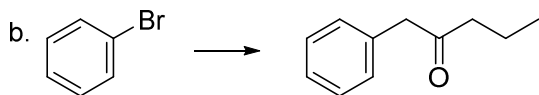
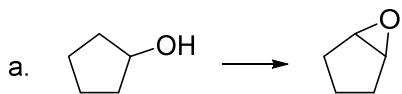
- 1) Treatment of 1,2,2-trimethylcycloheptanol with  $\text{H}_2\text{SO}_4$  gives a mixture of 1,7,7-trimethylcycloheptene and 1-*tert*-butylcyclohexene as the two major products. Write a reasonable mechanism to show how each of these products is formed. (20 pts)

- 2) You have found a mysterious bottle in your lab bench. The label is too covered in weird stains to be legible, but your research advisor assures you that this compound is vital to the success of your career as a chemistry grad student and you must identify its structure. Since the NMR is not available, you perform a few reactions and observe the following results.

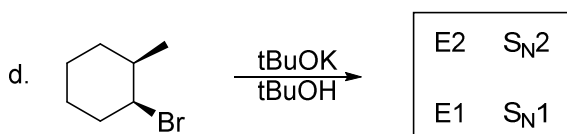
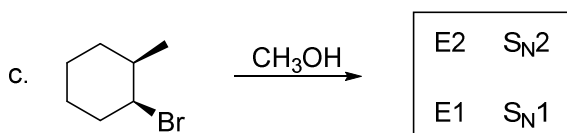
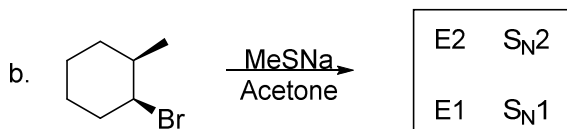
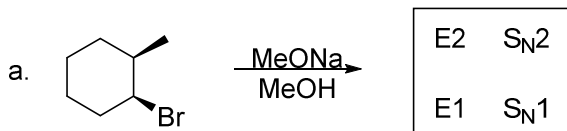


What is the structure of the compound in this mystery bottle? (20 pts)

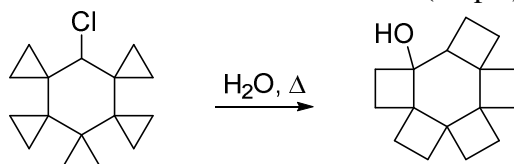
- 3) Find a way to synthesize the desired product from the given starting material. If more than one step is necessary, show the product of each step. Do not show mechanisms. (45 pts; 15 pts each)



- 4) For each of the reactions shown below, **circle the mechanism(s)** you would expect to see, if any, and **draw the product(s)**. If a product has stereocenters, show its configuration using wedges and dashes. If two stereoisomers are formed, show both of them. If an elimination occurs, show only the major alkene product. If none of the mechanisms would take place in a reasonable time frame, write NR for No Reaction. (20 pts total; 5 pts each)



- 5) The reaction shown below was observed to occur in water. (20 pts)



- a. Draw a reasonable mechanism for this reaction. (18 pts)

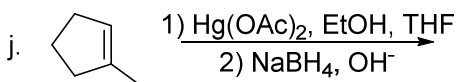
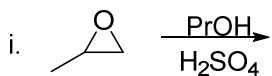
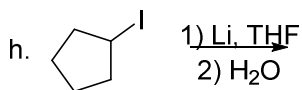
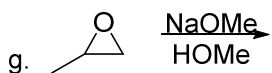
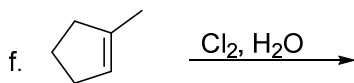
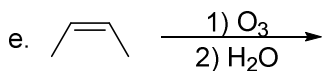
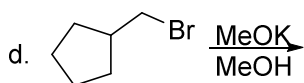
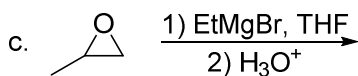
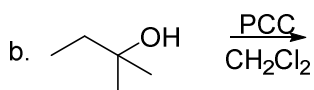
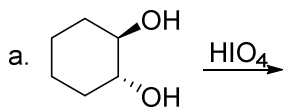
- b. Is this reaction awesome? Circle one answer. (2 pts)

Yes

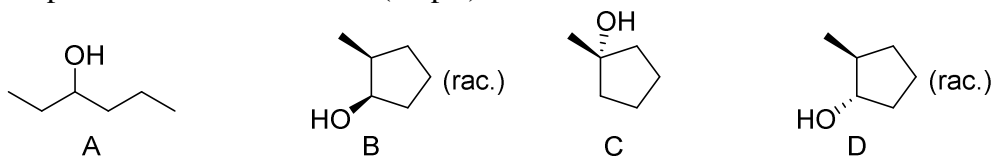
YES

VERY YES

- 6) **Predict the product** of the following reactions, and **choose the appropriate descriptor** (reduction, oxidation, or neither) for what happens to the organic molecule during each reaction. You do not need to show stereochemistry. (40 pts; 4 pts each)

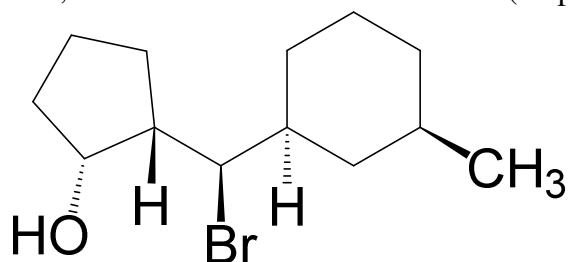


7) Four compounds are shown below. (20 pts)



- a. Which of these compounds can be synthesized as the major product of hydroboration-oxidation? Show the precursor alkene for each alcohol that can be prepared this way. (10 pts)
- b. Which of these compounds can be synthesized as the major product of oxymercuration-reduction? Show the precursor alkene for each alcohol that can be prepared this way. (10 pts)

8) In the structure shown below, label each stereocenter as R or S. (15 pts)



- 9) Extra credit! Three different alkanes are constitutional isomers, all with the formula  $C_6H_{12}$ . When treated with chlorine and UV light, under conditions that lead to monochlorination, isomer A gives a single product, isomer B (which contains a quaternary carbon) gives a mixture of three products, and isomer C gives a mixture of four products. Based on this information, draw the structures of all three isomers, and draw each of the monochlorination products that they form. (15 pts extra credit)