

# CHEM 3311 (Richardson) Third Hour Exam – April 12, 2016

Your Name Key

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

- Recitation Time
- 3:00 Monday w/ Blaine McCarthy
  - 11:00 Tuesday w/ Thomas Carey
  - 1:00 Wednesday w/ Garrett Cairo
  - 8:00 Thursday w/ Blaine McCarthy
  - 3:00 Thursday w/ Garrett Cairo

Question	Score	Out of
1		20
2		20
3		10
4		20
5		10
6		20
7		6 e.c.
<b>Total</b>		<b>100</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.

1 hydrogen <b>H</b> 1.0079																	2 helium <b>He</b> 4.0026						
3 lithium <b>Li</b> 6.941	4 beryllium <b>Be</b> 9.0122																	5 boron <b>B</b> 10.811	6 carbon <b>C</b> 12.011	7 nitrogen <b>N</b> 14.007	8 oxygen <b>O</b> 15.999	9 fluorine <b>F</b> 18.998	10 neon <b>Ne</b> 20.180
11 sodium <b>Na</b> 22.990	12 magnesium <b>Mg</b> 24.305																	13 aluminum <b>Al</b> 26.982	14 silicon <b>Si</b> 28.086	15 phosphorus <b>P</b> 30.974	16 sulfur <b>S</b> 32.065	17 chlorine <b>Cl</b> 35.453	18 argon <b>Ar</b> 39.948
19 potassium <b>K</b> 39.098	20 calcium <b>Ca</b> 40.078	21 scandium <b>Sc</b> 44.956	22 titanium <b>Ti</b> 47.867	23 vanadium <b>V</b> 50.942	24 chromium <b>Cr</b> 51.996	25 manganese <b>Mn</b> 54.938	26 iron <b>Fe</b> 55.845	27 cobalt <b>Co</b> 58.933	28 nickel <b>Ni</b> 58.693	29 copper <b>Cu</b> 63.546	30 zinc <b>Zn</b> 65.38	31 gallium <b>Ga</b> 69.723	32 germanium <b>Ge</b> 72.61	33 arsenic <b>As</b> 74.922	34 selenium <b>Se</b> 78.96	35 bromine <b>Br</b> 79.904	36 krypton <b>Kr</b> 83.80						
37 rubidium <b>Rb</b> 85.468	38 strontium <b>Sr</b> 87.62	39 yttrium <b>Y</b> 88.906	40 zirconium <b>Zr</b> 91.224	41 niobium <b>Nb</b> 92.906	42 molybdenum <b>Mo</b> 95.94	43 technetium <b>Tc</b> [98]	44 ruthenium <b>Ru</b> 101.07	45 rhodium <b>Rh</b> 102.91	46 palladium <b>Pd</b> 106.42	47 silver <b>Ag</b> 107.87	48 cadmium <b>Cd</b> 112.41	49 indium <b>In</b> 114.82	50 tin <b>Sn</b> 118.71	51 antimony <b>Sb</b> 121.76	52 tellurium <b>Te</b> 127.60	53 iodine <b>I</b> 126.90	54 xenon <b>Xe</b> 131.29						
55 cesium <b>Cs</b> 132.91	56 barium <b>Ba</b> 137.33	57-70 lanthanide series * <b>Lu</b> 174.97	71 hafnium <b>Hf</b> 178.49	72 tantalum <b>Ta</b> 180.95	73 tungsten <b>W</b> 183.84	74 rhenium <b>Re</b> 186.21	75 osmium <b>Os</b> 190.23	76 iridium <b>Ir</b> 192.22	77 platinum <b>Pt</b> 195.08	78 gold <b>Au</b> 196.97	79 mercury <b>Hg</b> 200.59	80 thallium <b>Tl</b> 204.38	81 lead <b>Pb</b> 207.2	82 bismuth <b>Bi</b> 208.98	83 polonium <b>Po</b> [209]	84 astatine <b>At</b> [210]	85 radon <b>Rn</b> [222]						
87 francium <b>Fr</b> [223]	88 radium <b>Ra</b> [226]	89-102 actinide series ** <b>Lr</b> [262]	103 rutherfordium <b>Rf</b> [261]	104 dubnium <b>Db</b> [262]	105 seaborgium <b>Sg</b> [263]	106 bohrium <b>Bh</b> [264]	107 hassium <b>Hs</b> [265]	108 meitnerium <b>Mt</b> [266]	109 darmstadtium <b>Uun</b> [267]	110 roentgenium <b>Uuu</b> [268]	111 copernicium <b>Uub</b> [269]	112 flerovium <b>Uuq</b> [270]											

\* Lanthanide series

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

\*\* Actinide series

## pKa Values

HI	-10	HF	3.2	HCN	9.4	HC≡CH	26
HBr	-8	CH <sub>3</sub> COOH	4.7	PhOH	10	H <sub>2</sub>	35
HCl	-6	HN <sub>3</sub>	4.7	RSH	10-12	NH <sub>3</sub>	36
H <sub>3</sub> O <sup>+</sup>	-1.7	H <sub>2</sub> S	7.0	H <sub>2</sub> O	15.7	H <sub>2</sub> C=CH <sub>2</sub>	45
ROH <sub>2</sub> <sup>+</sup>	-2	NH <sub>4</sub> <sup>+</sup>	9.3	ROH	15-19	CH <sub>4</sub>	60

Average = 68.1

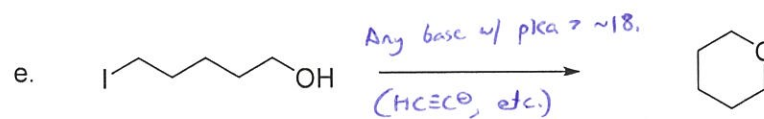
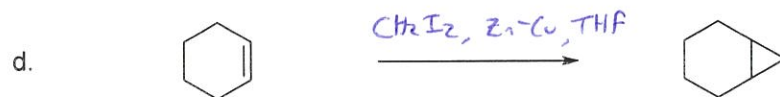
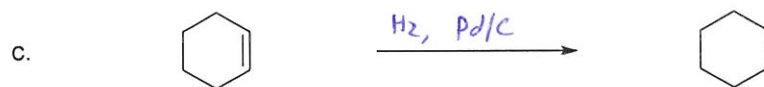
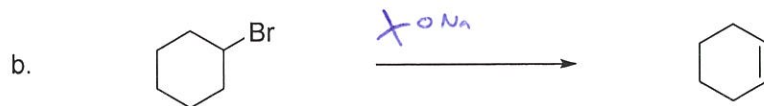
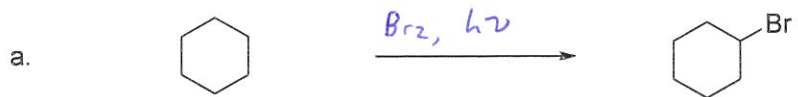
St. Dev = 21.1

Max = 102

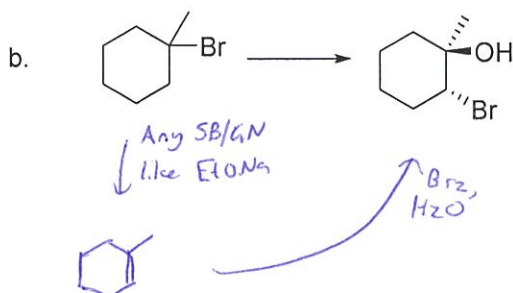
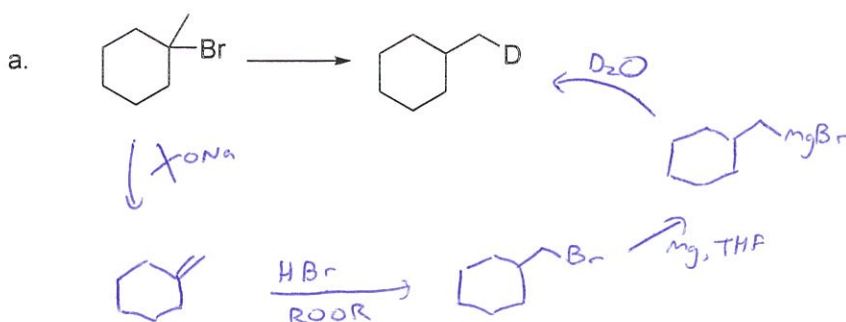
Min = 5

(Add 10-point curve to these numbers)

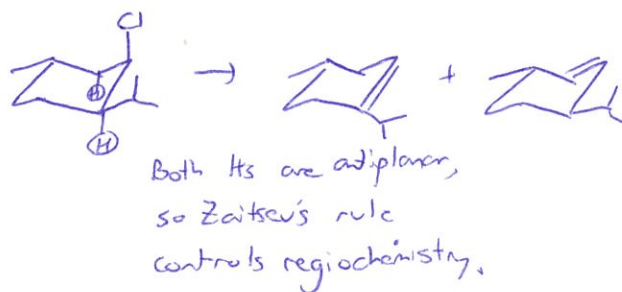
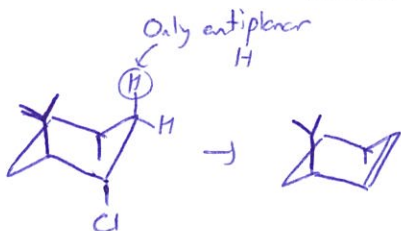
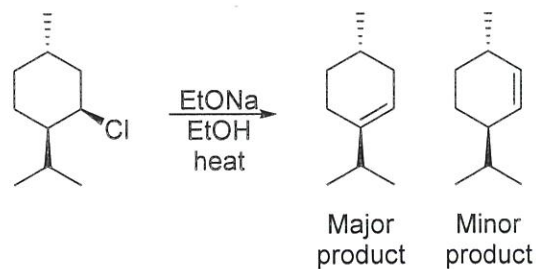
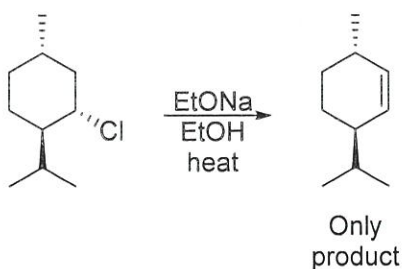
1) For each reaction shown below, write the necessary reagents on the arrow. The product shown should be the only major product. (20 pts)



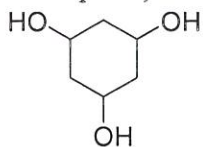
- 2) Find a way to synthesize the desired product from the given starting material. If more than one step is necessary, show the product of each step. Do not show mechanisms. (20 pts)



- 3) When the two alkyl chlorides shown below react with sodium ethoxide in ethanol at high temperatures, they give the products shown. Using 30 words or less, plus any necessary structures or mechanisms, explain why this happens. (10 pts)

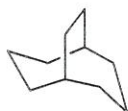


- 4) Provide an IUPAC name for each of these molecules (you do not need to include R/S or E/Z descriptors) and give the dominant intermolecular force for each one. (20 pts)



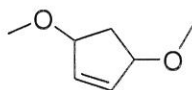
1,3,5-cyclohexanetriol  
(or cyclohexane-1,3,5-triol)

H-bonding



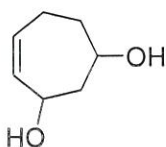
bicyclo[3.3.2]decane

van der Waals



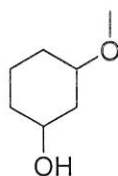
3,5-dimethoxy-1-cyclopentene  
(or 3,5-dimethoxycyclopent-1-ene)

Dipole-dipole



Cyclohept-4-ene-1,3-diol  
↳ ok if missing this "e"  
due to error in notes

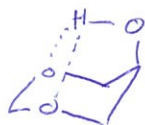
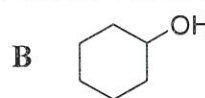
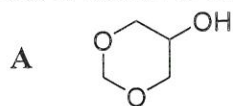
H-bonding



3-methoxycyclohexanol  
(or 3-methoxy-1-cyclohexanol)

H-bonding

- 5) Two compounds are shown below. Compound B exists mostly in the chair form with its OH group equatorial, but compound A exists mostly in the chair form with its OH group axial. Using 30 words or less, plus any necessary structures, explain why this happens. Hint: What intermolecular forces are available to one molecule, but not the other? (10 pts)

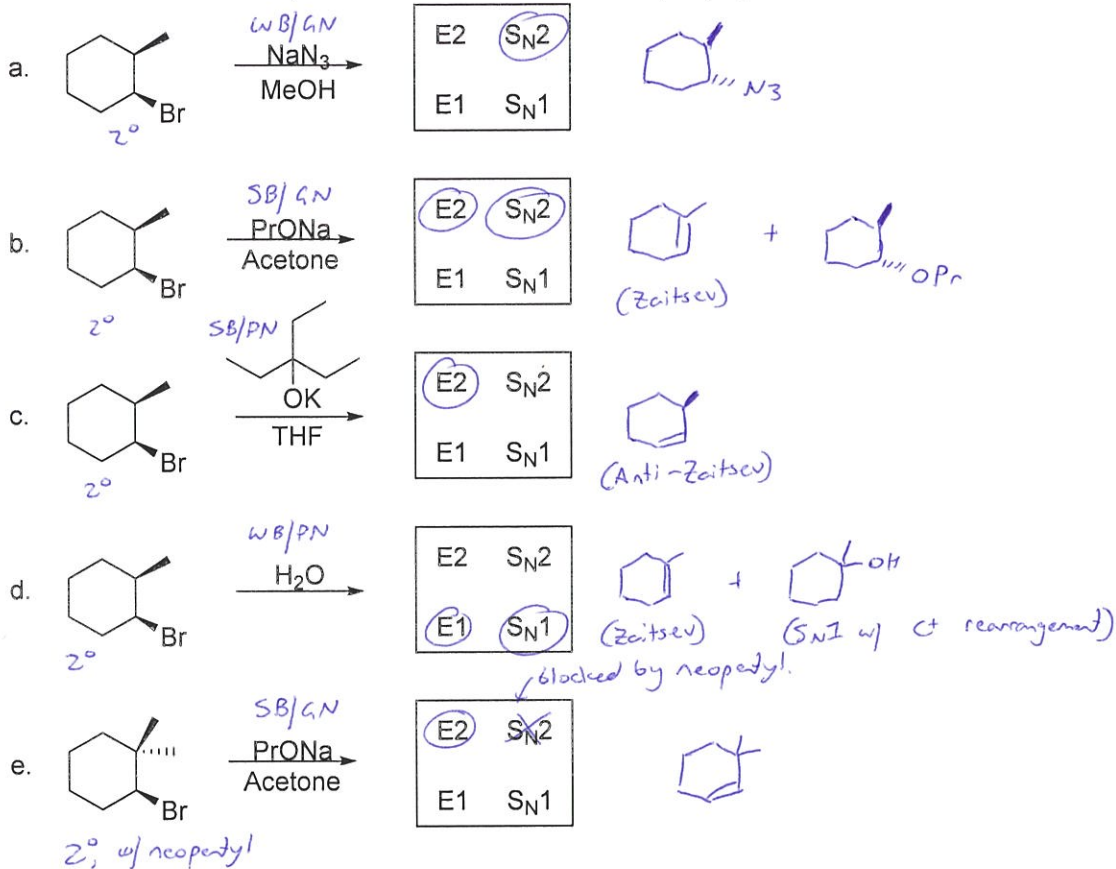


For A, when OH is axial, it can H-bond to O atoms in ring.



B has no similar benefit for axial OH.

- 6) 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)



- 7) Extra credit! Identify the HOMO and LUMO of each reaction. (6 pts e.c.)

