## CHEM 3311-200 (Ellison/Richardson) Final Exam – May 4, 2013

Your Name		Question	Score	Out of
		1		24
Student ID No.		2		10
		3		16
Recitation Day/Time		4		20
		5		40
Recitation TA (circle one)	Katelyn Chando,	6		30
	Setareh Azarnoush	7		10
		8		(10 ec)
		Total		150

This is a closed-book exam. The use of notes, calculators, scratch paper, 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	051																	helium 2
H																		Н́е
1.0079																		4.0026
ithium 3	beryllium 4												boron 5	carbon 6	nitrogen 7	oxygen 8	fluorine 9	neon 10
Ľi	Be												B	Č	Ň	Ŏ	Ě	Ne
6.941	9.0122												10.811	12.011	14.007	15,999	18,998	20,180
sodium	magnesium												aluminium	silicon	phosphorus	sulfur	chlorine	argon
11	12												13	14	15	16	17	18
Na	Mg												Al	Si	Р	S	CI	Ar
22.990	24.305												26.982	28.086	30.974	32.065	35.453	39.948
potassium 19	calcium 20		scandium 21	titanium 22	vanadium 23	chromium 24	manganese 25	iron 26	cobalt 27	nickel 28	copper 29	zinc 30	gallium 31	germanium 32	arsenic 33	selenium 34	bromine 35	krypton 36
	1: :1				1/	-		-										
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.098	40.078		44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.39	69.723	72.61	74.922	78.96	79.904	83.80
					50.942 nloblum 41									300000000000000000000000000000000000000				
39.098 rubidium <b>37</b>	40.078 strontium 38		44.956 yttrium	47.867 zirconium <b>40</b>	niobium 41	51.996 molybdenum 42	54.938 technetium 43	55.845 ruthenium 44	58.933 rhodium <b>45</b>	58.693 palladium 46	63.546 silver 47	65,39 cadmium <b>48</b>	69.723 Indium 49	72.61 tin <b>50</b>	74.922 antimony <b>51</b>	78.96 tellurlum <b>52</b>	79.904 lodine	83.80 xenon <b>54</b>
39.098 rubidium 37 <b>Rb</b>	strontium 38 Sr		44.956 yttrium 39	47.867 zirconium 40 Zr	Nb	51,996 molybdenum 42 Mo	54.938 technetium 43 <b>TC</b>	55.845 ruthenium 44 Ru	58.933 rhodium 45 <b>Rh</b>	58.693 palladium 46 Pd	63,546 silver 47 <b>Ag</b>	65.39 cadmium 48 Cd	69.723 Indium 49	72.61 tin 50 <b>Sn</b>	74.922 antimony 51 <b>Sb</b>	78.96 tellurium 52 <b>Te</b>	79.904 lodine 53	83.80 xenon 54 <b>Xe</b>
39.098 rubidium <b>37</b>	40.078 strontium 38		44.956 yttrium 39	47.867 zirconium <b>40</b>	niobium 41	51.996 molybdenum 42	54.938 technetium 43	55.845 ruthenium 44	58.933 rhodium <b>45</b>	58.693 palladium 46	63.546 silver 47	65,39 cadmium <b>48</b>	69.723 Indium 49	72.61 tin <b>50</b>	74.922 antimony <b>51</b>	78.96 tellurlum <b>52</b>	79.904 lodine	83.80 xenon <b>54</b>
39.098 rubidium 37 <b>Rb</b> 85.468	40.078 strontlum 38 <b>Sr</b> 87.62	57-70	44.956 yttrium 39 <b>Y</b> 88.906	47.867 zirconium 40 Zr 91.224 hafnium 72	niobium 41 <b>Nb</b> 92.906	51,996 molybdenum 42 Mo 95,94	54.938 technetium 43 <b>TC</b> [98]	55.845 ruthenium 44 <b>Ru</b> 101.07	58.933 rhodium 45 <b>Rh</b> 102.91	58.693 palladium 46 Pd 106.42	63.546 silver 47 <b>Ag</b> 107.87	65.39 cadmium 48 Cd 112.41 mercury 80	69.723 Indium 49 In	72.61 tin 50 <b>Sn</b>	74.922 antimony 51 Sb 121.76	78.96 tellurium 52 Te 127.60	79.904 lodine 53	83.80 xenon 54 Xe 131.29
39.098 rubidium 37 <b>Rb</b> 85.468 caesium	40.078 strontlum 38 <b>Sr</b> 87.62 barlum	57-70 <del>X</del>	44.956 yttrium 39 Y 88.906 lutetium	47.867 zirconium 40 Zr 91.224 hafnium	Nb 92,906 tantalum	51.996 molybdenum 42 Mo 95.94 tungsten	54.938 technetium 43 TC [98] rhenium	ruthenium 44 Ru 101.07 osmlum	58.933 rhodium 45 Rh 102.91 iridium	palladium 46 Pd 106.42 platinum	63.546 silver 47 Ag 107.87 gold	65.39 cadmium 48 Cd 112.41 mercury 80	69.723 Indium 49 In 114.82 thallium	72.61 tin 50 Sn 118.71 lead	74.922 antimony 51 Sb 121.76 bismuth	78.96 tellurium 52 Te 127.60 polonium	79.904 lodine 53 126.90 astatine	83.80 xenon 54 Xe 131.29 radon
39.098 rubidium 37 <b>Rb</b> 55.468 caesium 55 <b>Cs</b> 132.91	40.078 strontium 38 Sr 87.62 barlum 56 Ba 137.33		44.956 yttrium 39 Y 88.906 lutetium 71 Lu 174.97	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49	Nb 92.906 tantalum 73 Ta 180.95	51,996 molybdenum 42 MO 95,94 tungsten 74 W 183,84	technetium 43 TC 1981 rhenlum 75 Re 186.21	55.845 ruthenium 44 Ru 101.07 osmium 76 Os 190.23	58.933 fhodium 45 <b>Rh</b> 102.91 iridium 77 <b>Ir</b> 192.22	58.693 palladium 46 Pd 106.42 platinum 78 Pt 195.08	63.546 silver 47 Ag 107.87 gold 79 Au 196.97	65,39 cadmlum 48 Cd 112,41 mercury 80 Hg 200,59	69,723 Indium 49 In 114,82 thallium 81	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2	74.922 antimony 51 Sb 121.76 bismuth 83	78.96 tellurium 52 <b>Te</b> 127.60 polonium 84	79.904 lodine 53 126.90 astatine 85	83.80 xenon 54 Xe 131.29 radon 86
39.098 rubidium 37 Rb 85.468 caesium 55 Cs	40.078 strontlum 38 Sr 87.62 barlum 56 Ba 137.33 radium		44.956 yttrium 39 Y 88.906 lutetium 71 Lu	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf	Nb 92.906 tantalum 73	51.996 molybdenum 42 Mo 95.94 tungsten 74	technetium 43 Tc [98] menium 75 Re	ruthenium 44 Ru 101.07 osmium 76 Os	58.933 rhodium 45 Rh 102.91 iridium 77 Ir	palladium 46 Pd 108.42 platinum 78 Pt	63.546 sliver 47 <b>Ag</b> 107.87 gold 79 <b>Au</b>	cadmium 48 Cd 112.41 mercury 80 Hg 200.59 ununblum	69,723 Indium 49 In 114,82 thailium 81	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadium	74.922 antimony 51 Sb 121.76 bismuth 83 Bi	78.96 telurium 52 Te 127.60 potonium 84 Po	79.904 lodine 53 l 126.90 astatine 85 At	83.80 xenon 54 Xe 131.29 radon 86 Rn
39.098 rubidium 37 Rb 85.468 caesium 55 Cs 132.91 francium 87	40.078 strontum 38 Sr 87.62 barlum 56 Ba 137.33 radium 88	<del>×</del> 89-102	44,956 yttrium 39 Y 88,906 lutettum 71 Lu 174,97 lawrenclum 103	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49 rutherfordium 104	Nb 92.906 tantalum 73 Ta 180.95 dubnium 105	51,996 molybdenum 42 Mo 95,94 tungsten 74 W 183,84 seaborglum 106	technetium 43 TC [98] thenlum 75 Re 186,21 bohrlum 107	55,845 ruthenium 44 Ru 101,07 osmium 76 Os 190,23 hassium 108	58,933 rhodium 45 Rh 102,91 iridium 77 Ir 192,22 meitnerium 109	58.693 palladium 46 Pd 106.42 platinum 78 Pt 195.08 ununnilium 110	63.546 silver 47 Ag 107.87 gold 79 Au 196.97 unununium 111	65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59 unuriblum 112	69,723 Indium 49 In 114,82 thailium 81	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadium 114	74,922 antimony 51 Sb 121.76 bismuth 83 Bi 208.98	78.96 telurium 52 Te 127.60 potonium 84 Po	79.904 lodine 53 l 126.90 astatine 85 At	83.80 xenon 54 Xe 131.29 radon 86 Rn
39.098 rubidium 37 <b>Rb</b> 85.408 caesium 55 <b>Cs</b> 132.91 francium	40.078 strontlum 38 Sr 87.62 barlum 56 Ba 137.33 radium	*	44,956 yttrium 39 Y ss.906 lutetium 71 Lu 174,97 lawrenclum	47.867 zirconium 40 Zr 91.224 hatnium 72 Hf 178.49 rutherfordium	Nb 92,906 tantalum 73 Ta 180,95 dubnium	51,996 molybdenum 42 Mo 95,94 tungsten 74 W 183,84 seaborglum	54,938 technetium 43 TC [98] rhenlum 75 Re 186,21 bohrlum	55.845 ruthenium 44 Ru 101.07 osmium 76 Os 190.23 hassium	58,933 rhodium 45 Rh 102,91 iridium 77 Ir 192,22 metherium	58.693 palladium 46 Pd 106.42 platinum 78 Pt 195.08 ununnilium	63.546 silver 47 Ag 107.87 gold 79 Au 196.97 unununium 111	65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59 unuriblum 112	69,723 Indium 49 In 114,82 thailium 81	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadium	74,922 antimony 51 Sb 121.76 bismuth 83 Bi 208.98	78.96 telurium 52 Te 127.60 potonium 84 Po	79.904 lodine 53 l 126.90 astatine 85 At	83.80 xenon 54 Xe 131.29 radon 86 Rn

\*Lanthanide series

\* \* Actinide series

L	138.91	140.12	140.91	Nd 144,24	[145]	Sm 150.36	151.96	Gd 157,25	Tb	162.50	164.93	167.26	168.93	Yb 173.04
l	actinium 89	thorium 90	protactinium 91	uranium 92	neptunium 93	plutonium 94	americium 95	gurium 96	berkelium 97	californium 98	einsteinium 99	fermium 100	mendelevium 101	nobelium 102
			D -	1.1	Miles	PII	Α	0	Rk	05		E	Md	NI -
1	Ac	ın	Pa	U	Np	Pu	Am	Cm	BK	CT	Es	Fm	IVIC	No

pKa Values

		P		a co	
HI	-10	$HN_3$	4.7	$H_2O$	15.7
HBr	-8	$H_2S$	7.0	Alcohol (ROH)	16-18
HC1	-6	$\mathrm{NH_4}^+$	9.3	HC≡CH	26
$H_3O^+$	-1.7	HCN	9.4	Amines (e.g. LDA)	36
HF	3.2	Phenol	10	H <sub>2</sub> C=CH <sub>2</sub>	45
CH <sub>3</sub> COOH	4.7	RSH	10-12	CH <sub>4</sub>	60

1) **Show what reagents** you would use to synthesize this ether by each of the following methods, and **show the mechanism** by which the ether forms in each reaction. (8 pts each)



a. Williamson ether synthesis

b. Alkoxymercuration-reduction (do not show mechanism for reduction step)

c. Acid-catalyzed ether formation from alcohols

2) Write the names of the following functional groups. (1 pt each)





\_=

$$\overset{\mathsf{o}}{\downarrow}$$

\_0\_

\_s.

 $\bigcirc$ 

- 3) Acids and bases (16 pts)
  - a. For each pair of compounds shown below, select the more acidic of the two compounds and explain your reasoning in under ten words. (2 pts each)

vs.

Reason:

VS.

Reason:

Reason:

vs.

Reason:

b. For each of the following reactions, does the equilibrium favor the reactants or products? (2 pts each)

$$HF + H_2O \longrightarrow F^- + H_3O^+$$

$$CH_3S^- + CH_3NH_2 \rightarrow CH_3SH + CH_3NH^-$$

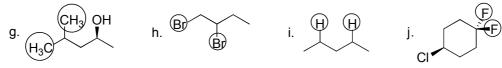
4) **Parts a – d:** Describe each of the following pairs of molecules as identical, enantiomers, diastereomers, or constitutional isomers. (2 pts each)

a. Me Me J

c. CI CI CI

Parts e-f: Describe each molecule as R or S at the stereocenter labeled with a \*. (2 pts each)

**Parts g – j:** Describe each of the following groups as homotopic, enantiotopic, diastereotopic, or constitutionally nonequivalent. (2 pts each)



5) **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. (4 pts each)

a. 
$$O$$
  $MeOH$ ,  $H_2SO_4$ 

c. 
$$\frac{1) \operatorname{Et_2CuLi, THF}}{2) \operatorname{H_3O^+}}$$

e. 
$$\sqrt{\frac{OsO_4, H_2O_4}{TMAO}}$$

6) 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. (10 pts each)

a. 
$$\bigcirc$$
 Br  $\longrightarrow$  Br

7) Draw the following molecules in **both** chair conformations, and circle the most stable. (5 pts each)

8) Extra credit! Write the mechanism for the following reaction. (10 pts extra credit)  $\frac{OH}{CH_3OH}$   $\frac{H_2SO_4}{CH_3OH}$