

# CHEM 3311 (Richardson) Final Exam – Dec. 18, 2018

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

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

- Recitation (check one)      O 10:00 Mon (Shafer Soars)  
 O 11:00 Mon (Matthew Farmer)      O 1:00 Mon (Lacey Wayment)  
 O 2:00 Mon (Shaofeng Huang)      O 3:00 Mon (Shaofeng Huang)  
 O 9:00 Tue (Lacey Wayment)      O 10:00 Tue (Josh Kamps)  
 O 12:00 Tue (Josh Kamps)      O 2:00 Tue (Lauren Bodkin)  
 O 3:00 Tue (Lauren Bodkin)      O 4:00 Tue (Matthew Farmer)

Question	Score	Out of
1		30
2		15
3		40
4		40
5		20
6		20
7		15
8		20
9		10 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 <b>H</b> 1.0079																	helium 2 <b>He</b> 4.0026						
lithium 3 <b>Li</b> 6.941	beryllium 4 <b>Be</b> 9.0122																	boron 5 <b>B</b> 10.811	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.007	oxygen 8 <b>O</b> 15.999	fluorine 9 <b>F</b> 18.998	neon 10 <b>Ne</b> 20.180
sodium 11 <b>Na</b> 22.990	magnesium 12 <b>Mg</b> 24.305																	aluminum 13 <b>Al</b> 26.982	silicon 14 <b>Si</b> 28.086	phosphorus 15 <b>P</b> 30.974	sulfur 16 <b>S</b> 32.065	chlorine 17 <b>Cl</b> 35.453	argon 18 <b>Ar</b> 39.948
potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078	scandium 21 <b>Sc</b> 44.956	titanium 22 <b>Ti</b> 47.867	vanadium 23 <b>V</b> 50.942	chromium 24 <b>Cr</b> 51.996	manganese 25 <b>Mn</b> 54.938	iron 26 <b>Fe</b> 55.845	cobalt 27 <b>Co</b> 58.933	nickel 28 <b>Ni</b> 58.693	copper 29 <b>Cu</b> 63.546	zinc 30 <b>Zn</b> 65.39	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	seletem 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	krypton 36 <b>Kr</b> 83.80						
rubidium 37 <b>Rb</b> 85.468	strontium 38 <b>Sr</b> 87.62	yttrium 39 <b>Y</b> 88.906	zirconium 40 <b>Zr</b> 91.224	niobium 41 <b>Nb</b> 92.906	molybdenum 42 <b>Mo</b> 95.94	technetium 43 <b>Tc</b> [98]	ruthenium 44 <b>Ru</b> 101.07	rhodium 45 <b>Rh</b> 102.91	palladium 46 <b>Pd</b> 106.42	silver 47 <b>Ag</b> 107.87	cadmium 48 <b>Cd</b> 112.41	indium 49 <b>In</b> 114.82	tin 50 <b>Sn</b> 118.71	antimony 51 <b>Sb</b> 121.76	tellurium 52 <b>Te</b> 127.60	iodine 53 <b>I</b> 126.90	xenon 54 <b>Xe</b> 131.29						
cesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33	* 57-70	lutetium 71 <b>Lu</b> 174.97	hafnium 72 <b>Hf</b> 178.49	tantalum 73 <b>Ta</b> 180.95	tungsten 74 <b>W</b> 183.84	rhenium 75 <b>Re</b> 186.21	osmium 76 <b>Os</b> 190.23	iridium 77 <b>Ir</b> 192.22	platinum 78 <b>Pt</b> 195.08	gold 79 <b>Au</b> 196.97	mercury 80 <b>Hg</b> 200.59	thallium 81 <b>Tl</b> 204.38	lead 82 <b>Pb</b> 207.2	bismuth 83 <b>Bi</b> 208.98	polonium 84 <b>Po</b> [209]	astatine 85 <b>At</b> [210]	radon 86 <b>Rn</b> [222]					
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]	* *	lawrencium 103 <b>Lr</b> [262]	rutherfordium 104 <b>Rf</b> [261]	dubnium 105 <b>Db</b> [262]	seaborgium 106 <b>Sg</b> [266]	bohrium 107 <b>Bh</b> [264]	hassium 108 <b>Hs</b> [265]	meitnerium 109 <b>Mt</b> [268]	unnilium 110 <b>Uun</b> [271]	ununium 111 <b>Uuu</b> [272]	unbibium 112 <b>Uub</b> [277]	unbiquadium 114 <b>Uuq</b> [289]										

\* Lanthanide series

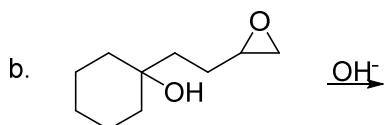
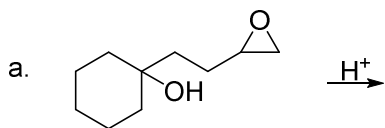
lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [145]	samarium 62 <b>Sm</b> 150.36	europium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium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

\*\* Actinide series

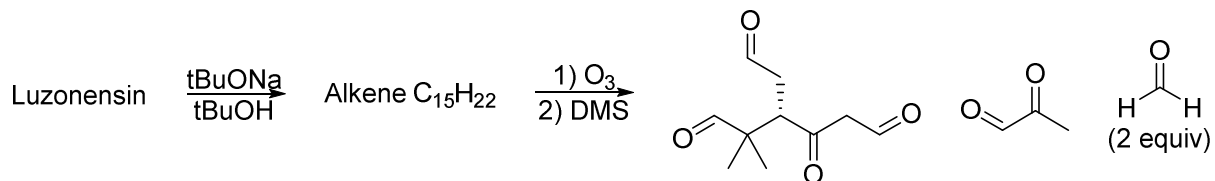
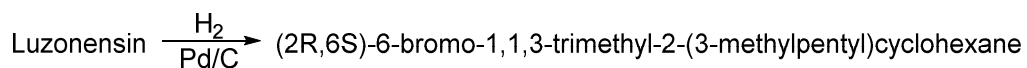
## pKa Values

HI	-10	CH <sub>3</sub> COOH	4.7	ArOH	10	HC≡CH	26
HBr	-8	HN <sub>3</sub>	4.7	RSH	10-12	H <sub>2</sub>	35
HCl	-6	H <sub>2</sub> S	7.0	H <sub>2</sub> O	15.7	NH <sub>3</sub>	36
H <sub>3</sub> O <sup>+</sup>	-1.7	NH <sub>4</sub> <sup>+</sup>	9.3	ROH	16-18	H <sub>2</sub> C=CH <sub>2</sub>	45
HF	3.2	HCN	9.4	O=C-CH	9-25	CH <sub>4</sub>	60

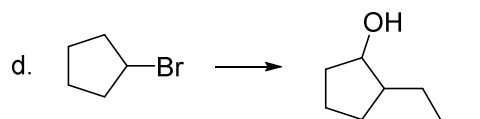
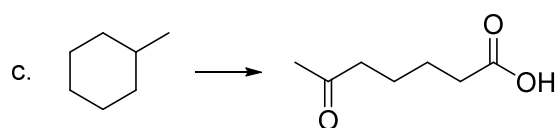
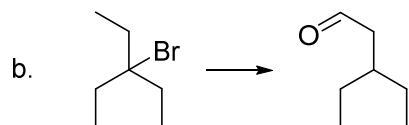
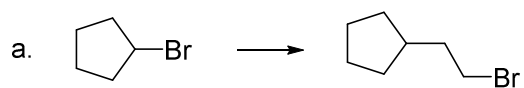
- 1) Each of these reactions forms a different product of formula  $C_{10}H_{18}O_2$ . Show a mechanism for each reaction, and draw a box around the final product. (30 pts - 15 pts each)



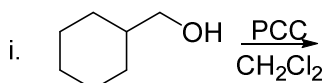
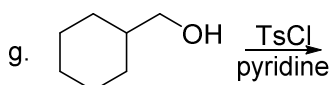
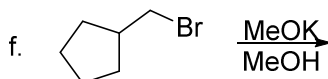
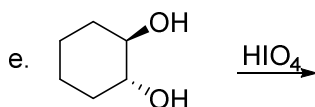
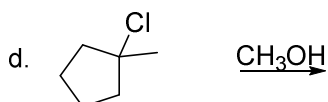
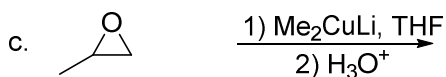
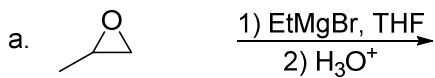
- 2) In your lab, you have found a mysterious bottle labeled “Luzonensin – isolated from red algae *Laurencia luzonensis*.” In an attempt to discover its structure, you perform some reactions on it and observe the following results. What is the structure of luzonensin? (15 pts)



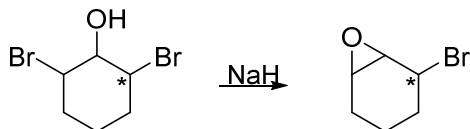
- 3) Find a way to synthesize the desired product from the given starting material. If more than one step is necessary, show the product of each step. Do not show mechanisms. (40 pts - 10 pts each)



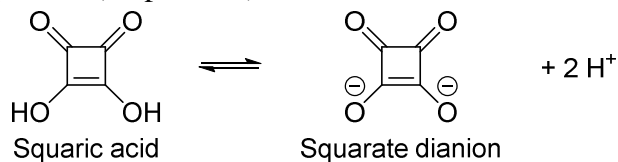
- 4) **Predict the product** of the following reactions, and **choose the appropriate descriptor** (reduction, oxidation, or neither) for what happens to the organic molecule during each reaction. You do not need to show stereochemistry. (40 pts; 4 pts each)



- 5) One particular stereoisomer of 2,6-dibromocyclohexanol was labeled with a carbon isotope (indicated by an asterisk) at one of the bromine-bearing carbons. When this compound was treated with sodium hydride, it formed **only** the product shown. Draw the stereoisomer of 2,6-dibromocyclohexanol that is consistent with these results, and explain why in under 30 words, but with as many structures as you want. (20 pts)



- 6) Squaric acid, shown below, can lose two protons to become the squarate dianion. Answer these questions about squarate. (20 pts total)

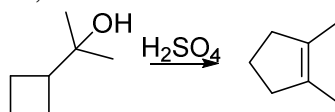


- a. Draw three other resonance forms for the squarate dianion. Use valid arrow-pushing to show the movement of electrons. (5 pts each)

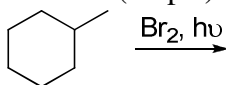


- b. What is the average bond order for each C-O bond in this structure? (2 pts)
- c. What is the average bond order for each C-C bond in this structure? (3 pts)

- 7) Show a mechanism for this reaction, and draw a box around the final product. (15 pts)



- 8) Show a mechanism for this reaction (ignoring stereochemistry), and draw a box around the final product. Clearly label your initiation, propagation and termination steps, and show at least two examples of termination. (20 pts)



- 9) Extra credit! The structure of ethynyl estradiol, an oral contraceptive, is shown below. For each of the labeled atoms, describe the hybridization as  $sp$ ,  $sp^2$ , or  $sp^3$ . (10 pts extra credit)

