

# CHEM 3311 (Richardson) First Hour Exam – February 9, 2016

Your Name \_\_\_\_\_ **KEY**

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

- Recitation Time (check one)
- 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		15
3		12
4		8
5		21
6		12
7		12
<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.

hydrogen 1 <b>H</b> 1.00794																	helium 2 <b>He</b> 4.002602						
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> 47.887	vandium 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> 65.38	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.64	arsenic 33 <b>As</b> 74.922	selenium 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	lanthanide series 57-70 * 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]	actinide series 89-102 * * 103 <b>Lr</b> [260]	rutherfordium 104 <b>Rf</b> [261]	bohrium 105 <b>Db</b> [262]	seaborgium 106 <b>Sg</b> [263]	meitnerium 107 <b>Bh</b> [264]	hassium 108 <b>Hs</b> [265]	tennessine 109 <b>Mt</b> [266]	unbinetium 110 <b>Uun</b> [267]	ununbium 111 <b>Uuu</b> [268]	ununtrium 112 <b>Uub</b> [269]	copernicium 114 <b>Uuq</b> [270]											

* Lanthanide series	57 <b>La</b> 138.91	58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> [145]	62 <b>Sm</b> 150.36	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.93	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04
** Actinide series	89 <b>Ac</b> [227]	90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> [237]	94 <b>Pu</b> [244]	95 <b>Am</b> [243]	96 <b>Cm</b> [247]	97 <b>Bk</b> [247]	98 <b>Cf</b> [251]	99 <b>Es</b> [252]	100 <b>Fm</b> [257]	101 <b>Md</b> [258]	102 <b>No</b> [259]

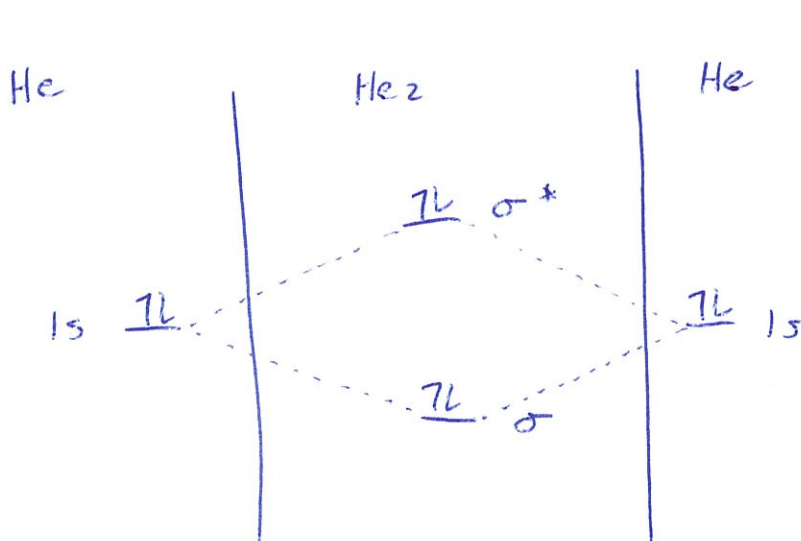
## pKa Values

HI	-10	CH <sub>3</sub> COOH	4.7	Phenol	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	Alcohol (ROH)	16-18	CH <sub>4</sub>	60
HF	3.2	HCN	9.4	HC≡CH	26		

Average: 76.6  
St. Dev: 14.5  
Max: 95  
Min: 17.5

## 1) Molecular Orbitals (20 pts total)

- a. Helium, being a noble gas, is well-known for its unwillingness to form bonds to other atoms. Draw an MO diagram for the hypothetical He<sub>2</sub> molecule, being sure to name each orbital and fill in electrons correctly. (10 pts)



- 2 for not adding e<sup>-</sup> properly
- 5 for making up orbitals
- 2 for wrong # of e<sup>-</sup>
- 1 for labeling  $\sigma$  or  $\sigma^*$  wrong

- b. What is the bond order between the two helium atoms in this molecule? (5 pts)

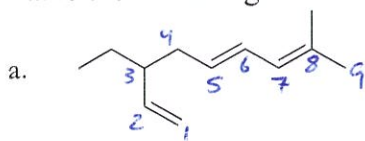
$$\frac{(2-2)}{2} = 0$$

- c. In twenty words or less, explain why He<sub>2</sub> does not exist. (5 pts)

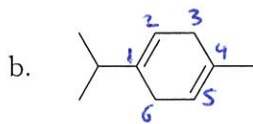
The bond order is zero because the bonding & antibonding MOs are equally full, so there's no energy benefit.

-1 for filled "odd," not "even"

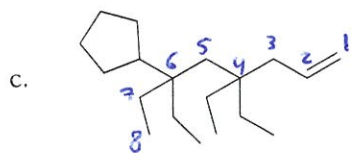
2) Name the following structures. You do not need to use E/Z descriptors. (15 pts)



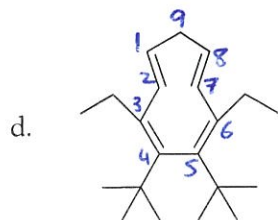
3-ethyl-8-methyl-1,5,7-<sup>nonatriene</sup>~~triene~~  
(or 3-ethyl-8-methylnona-1,5,7-triene)



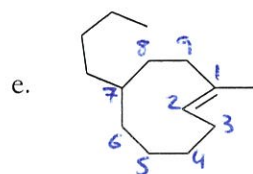
1-isopropyl-4-methyl-1,4-<sup>cyclo</sup>hexadiene  
(or 1-isopropyl-4-methyl<sup>cyclo</sup>hexa-1,4-diene)



6-cyclopentyl-4,4,6-triethyl-1-octene  
(or 6-cyclopentyl-4,4,6-triethyloct-1-ene)



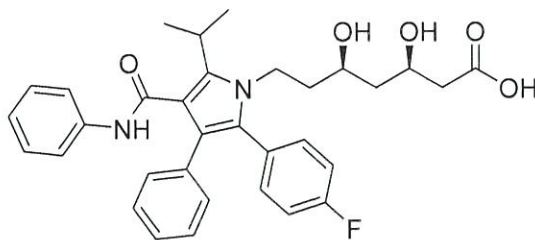
4,5-di-tert-butyl-3,6-diethyl-1,3,5,7-cyclononatriene  
(or 4,5-di-tert-butyl-3,6-diethylcyclonona-1,3,5,7-triene)



7-butyl-1-methylcyclononene  
(or 7-butyl-1-methylcyclonon-1-ene)

3 pts each.  
-2 for wrong parent chain  
-1 for wrong numbering  
-1 for naming sub groups wrong  
-1 for bad alphabetizing  
-1 for wrong suffix

3) Lipitor, shown below, is a statin used to lower cholesterol and is the best-selling pharmaceutical of all time. Which of the listed functional groups does Lipitor contain? Circle all that apply. (6 pts)



2 pts each  
(-2 for each wrong choice)

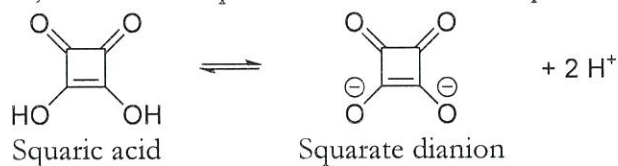
<u>Alkyl halide</u>	Ketone	<u>Amide</u>	<u>Amine</u>	<u>Aromatic ring</u>
<u>Alcohol</u>	Ether	Ester	Aldehyde <del>Alkene</del>	<u>Carboxylic acid</u>

- 4) Draw all the cycloalkanes with formula  $C_4H_7Br$ , using bond-line structures. Be careful not to repeat any structures. You only need to show connectivity – no stereochemistry or bold/dashed bonds are necessary. (8 pts)



2 pts each

- 5) Squaric acid, shown below, can lose two protons to become the squarate dianion.



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



for each form: 3 pts for structure, 2 pts for arrows to get there.

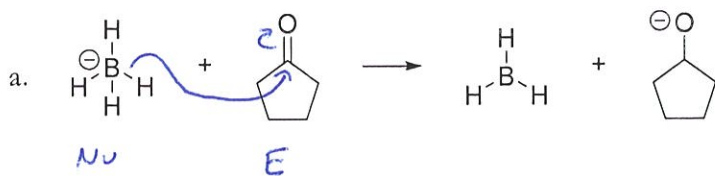
- b. What is the average bond order for each C-O bond in this structure? (3 pts)

$$\frac{(2+2+1+1)}{4} = 1\frac{1}{2} \text{ for each C-O bond (they're all equivalent)}$$

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

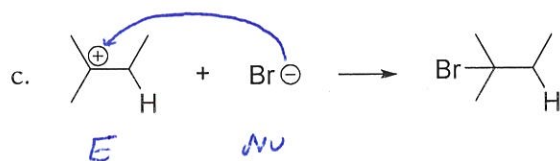
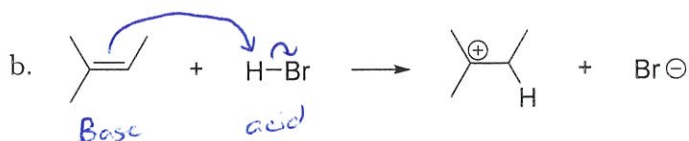
$$\frac{(2+1+1+1)}{4} = 1\frac{1}{4} \text{ for each C-C bond (they're all equivalent)}$$

- 6) Complete each arrow-pushing mechanism and identify each reactant as a nucleophile, electrophile, acid, or base. (12 pts)



For each: 2 pts for labels,  
1 pt for arrows

-0.5 if 2 labels applied to  
same molecule.

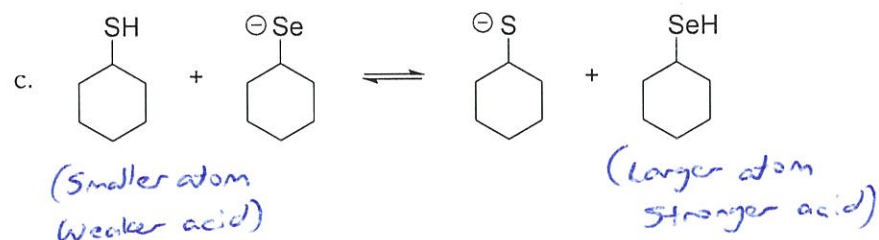
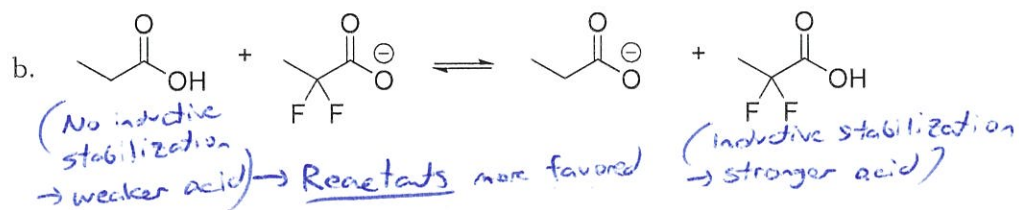


- 7) For each of the following reactions, does the equilibrium favor the reactants or products? (12 pts)



( $\text{pK}_a = 15.7$ ) ( $\text{pK}_a = 26$ )  
weaker acid = Products more favored

For each: <sup>4</sup> 3 pts



↓  
Reactants more favored.