

CHEM 3311 (Richardson) First Hour Exam – Sep. 26, 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		18
2		12
3		10
4		20
5		16
6		6
7		18
Total		

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 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		scandium 21 Sc 44.956		titanium 22 Ti 47.867		vanadium 23 V 50.942		chromium 24 Cr 51.996		manganese 25 Mn 54.938		iron 26 Fe 55.845		cobalt 27 Co 58.933		nickel 28 Ni 58.693		copper 29 Cu 63.546		zinc 30 Zn 65.39		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		yttrium 39 Y 88.906		zirconium 40 Zr 91.224		niobium 41 Nb 92.906		molybdenum 42 Mo 95.94		technetium 43 Tc [98]		ruthenium 44 Ru 101.07		rhodium 45 Rh 102.91		palladium 46 Pd 106.42		silver 47 Ag 107.87		cadmium 48 Cd 112.41		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			
cesium 55 Cs 132.91		barium 56 Ba 137.33		* 57-70 *		* 71 * lutetium Lu 174.97		* 72 * hafnium Hf 178.49		* 73 * tantalum Ta 180.95		* 74 * tungsten W 183.84		* 75 * rhenium Re 186.21		* 76 * osmium Os 190.23		* 77 * iridium Ir 192.22		* 78 * platinum Pt 195.08		* 79 * gold Au 196.97		* 80 * mercury Hg 200.59		* 81 * thallium Tl 204.38		* 82 * lead Pb 207.2		* 83 * bismuth Bi 208.98		* 84 * polonium Po [209]		* 85 * astatine At [210]		* 86 * radon Rn [222]	
francium 87 Fr [223]		radium 88 Ra [226]		* 89-102 *		* 103 * lawrencium Lr [262]		* 104 * rutherfordium Rf [261]		* 105 * dubnium Db [262]		* 106 * seaborgium Sg [263]		* 107 * bohrium Bh [264]		* 108 * hassium Hs [265]		* 109 * meitnerium Mt [266]		* 110 * darmstadtium Ds [267]		* 111 * roentgenium Rg [268]		* 112 * copernicium Cn [269]		* 113 * nihonium Nh [270]		* 114 * flerovium Fl [271]		* 115 * moscovium Mc [272]		* 116 * livermorium Lv [273]		* 117 * tennessine Ts [274]		* 118 * oganeson Og [275]	

* Lanthanide series

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
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* * Actinide series

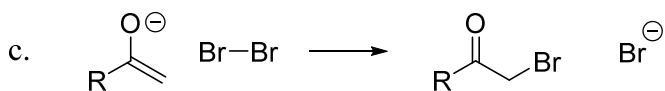
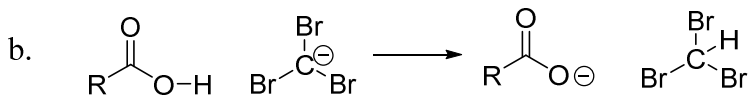
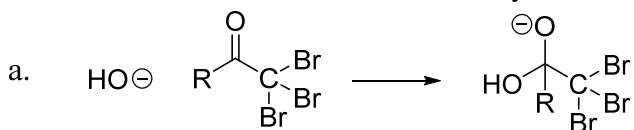
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]
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pKa Values

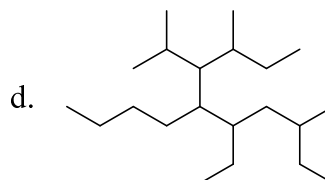
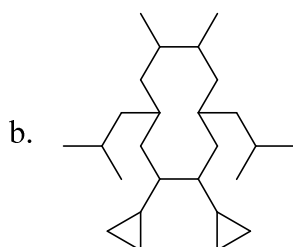
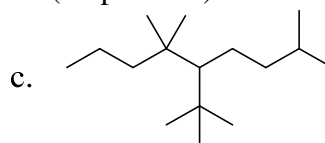
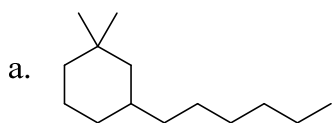
HI	-10	CH ₃ COOH	4.7	ArOH	10	H ₂	35
HBr	-8	HN ₃	4.7	RSH	10-12	NH ₃	36
HCl	-6	H ₂ S	7.0	H ₂ O	15.7	H ₂ C=CH ₂	45
H ₃ O ⁺	-1.7	NH ₄ ⁺	9.3	ROH (R=alkyl)	16-18	CH ₄	60
HF	3.2	HCN	9.4	HC≡CH	26		

1) For the following reactions, complete these steps: (18 pts total)

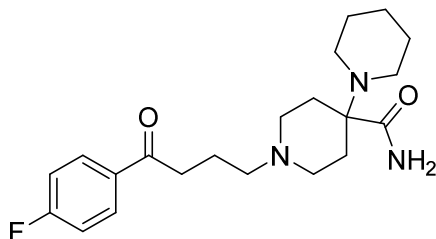
- add arrows to show the movement of electrons (2 pts per problem)
- classify each species as either an acid, base, nucleophile, or electrophile (2 pts per problem). Please use the labels “nucleophile” and “electrophile” only for things that are NOT acting as acids/bases.
- identify the HOMO and LUMO for each reaction (2 pts per problem). Hint for c: the HOMO is the orbital that directly attacks the other molecule.



2) Give the IUPAC names for the following structures. (12 pts total)



3) Pipamperone, shown below, is an antipsychotic used for the treatment of schizophrenia. Which of the listed functional groups does pipamperone contain? Circle all that apply. (10 pts)



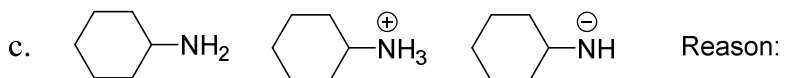
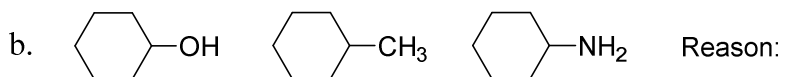
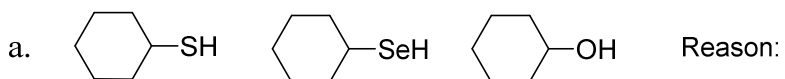
Alcohol	Aldehyde	Alkene	Amide	Amine
Aromatic ring	Ester	Ether	Alkyl/aryl halide	Ketone

- 4) Lewis structure and Molecular Orbitals (20 pts total)
- Draw a Lewis structure for acetylene, C_2H_2 . (4 pts)
 - What is the hybridization of each carbon atom in this structure? (2 pts)
 - How many σ and how many π bonds are there between the two carbon atoms? (2 pts)
 - Generate an MO diagram for the C-C triple bond in acetylene, given that any π orbitals will be at the same energy level as each other. Ignore the atomic orbitals and electrons used for bonding to hydrogen atoms, and do not show 1s orbitals. (10 pts)
 - What is the bond order between the two carbons, according to the MO diagram? (2 pts)

- 5) Cyclopentadiene, shown below, is surprisingly acidic for an organic compound. It loses a proton very easily from its sp^3 -hybridized carbon. (16 pts total)

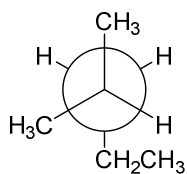
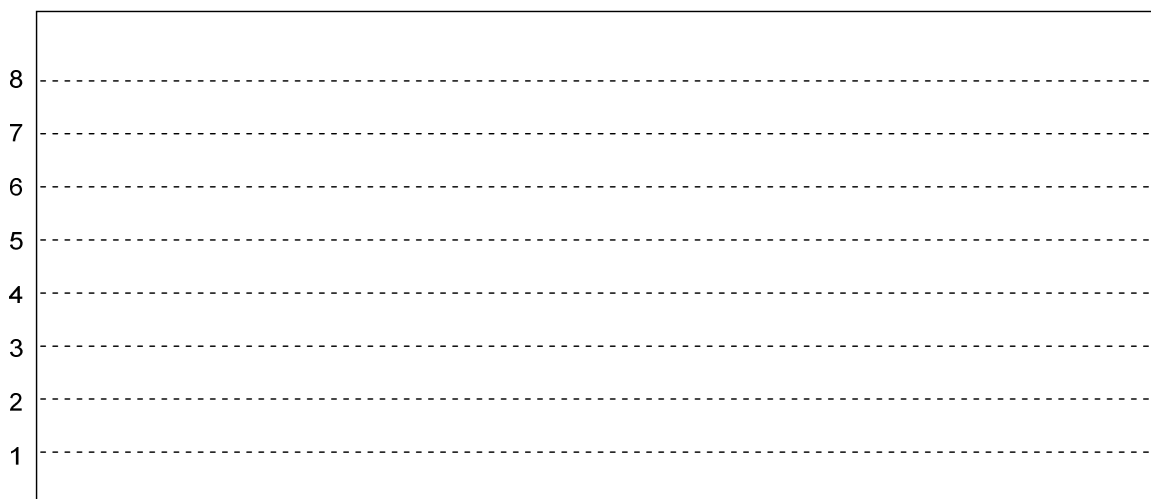


- Draw the conjugate base of cyclopentadiene. (2 pts)
 - Show all the major resonance forms of the conjugate base (starting with the structure you drew for part a.), using arrow-pushing to move from one form to the next. (8 pts)
 - What is the average charge on each carbon atom? (3 pts)
 - What is the average C-C bond order? (3 pts)
- 6) For each set of compounds shown below, rank them by acidity (1=highest pKa, 3 = lowest pKa) and explain your reasoning in twenty words or less per explanation. (6 pts)



- 7) Draw the structure of 2-methylpentane. Sighting along the bond between carbon 2 and carbon 3 (as numbered by IUPAC), show a Newman projection for the molecule's conformations for dihedral angles in increments of 60° . **Keep the front atom stationary and rotate the back atom clockwise.** For each conformation, plot these energy levels and create a conformational energy diagram. You do not need to calculate the exact energy for each level – a rough estimate is acceptable, so long as the relative ordering of levels is correct. If the energy of a particular interaction is not shown in this table, assume it is zero. (18 pts)

Interaction	Energy (kcal/mol)
H/H eclipsed	1
Me/H eclipsed	1.15
Et/H eclipsed	1.25
Me/Me eclipsed	3.6
Me/Et eclipsed	3.9
Me/Me gauche	0.67
Me/Et gauche	0.75



Interactions:

1 x
Me/Et
gauche

Interactions:

Interactions:

Interactions:

Interactions:

Interactions:

Interactions: