

First Midterm Exam

Monday, October 16, 2017

Name _____

You may use model kits but no other material with chemical information without instructor approval.

Please do not use any electronic devices (calculators, phones, ipods, smart watches).

IUPAC Periodic Table of the Elements

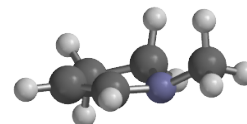
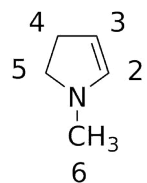
1 H hydrogen 1.008 [1.0078, 1.0082]																	2 He helium 4.0026
3 Li lithium 6.94 [6.938, 6.997]	4 Be beryllium 9.0122											5 B boron 10.81 [10.806, 10.821]	6 C carbon 12.011 [12.009, 12.012]	7 N nitrogen 14.007 [14.006, 14.008]	8 O oxygen 15.999 [15.998, 16.000]	9 F fluorine 18.998	10 Ne neon 20.180
11 Na sodium 22.990 [22.989, 22.991]	12 Mg magnesium 24.305 [24.304, 24.307]											13 Al aluminum 26.982 [26.981, 26.983]	14 Si silicon 28.086 [28.085, 28.087]	15 P phosphorus 30.974 [30.973, 30.975]	16 S sulfur 32.06 [32.059, 32.071]	17 Cl chlorine 35.45 [35.446, 35.457]	18 Ar argon 39.948
19 K potassium 39.098 [39.096, 39.100]	20 Ca calcium 40.078(4)	21 Sc scandium 44.956 [44.955, 44.957]	22 Ti titanium 47.867 [47.867, 47.867]	23 V vanadium 50.942 [50.942, 50.942]	24 Cr chromium 51.996 [51.996, 51.996]	25 Mn manganese 54.938 [54.938, 54.938]	26 Fe iron 55.845(2)	27 Co cobalt 58.933 [58.933, 58.933]	28 Ni nickel 58.693 [58.693, 58.693]	29 Cu copper 63.546(3)	30 Zn zinc 65.38(2)	31 Ga gallium 69.723 [69.723, 69.723]	32 Ge germanium 72.630(8)	33 As arsenic 74.922 [74.922, 74.922]	34 Se selenium 78.971(8)	35 Br bromine 79.904 [79.901, 79.907]	36 Kr krypton 83.796(2)
37 Rb rubidium 85.468 [85.468, 85.468]	38 Sr strontium 87.62 [87.62, 87.62]	39 Y yttrium 88.906 [88.906, 88.906]	40 Zr zirconium 91.224(2)	41 Nb niobium 92.906 [92.906, 92.906]	42 Mo molybdenum 95.94 [95.94, 95.94]	43 Tc technetium 98 [98, 98]	44 Ru ruthenium 101.07(2)	45 Rh rhodium 102.91 [102.91, 102.91]	46 Pd palladium 106.42 [106.42, 106.42]	47 Ag silver 107.87 [107.87, 107.87]	48 Cd cadmium 112.41 [112.41, 112.41]	49 In indium 114.82 [114.82, 114.82]	50 Sn tin 118.71 [118.71, 118.71]	51 Sb antimony 121.76 [121.76, 121.76]	52 Te tellurium 127.60(3)	53 I iodine 126.90 [126.90, 126.90]	54 Xe xenon 131.29 [131.29, 131.29]
55 Cs caesium 132.91 [132.91, 132.91]	56 Ba barium 137.33 [137.33, 137.33]	57-71 lanthanoids	72 Hf hafnium 178.49(2)	73 Ta tantalum 180.95 [180.95, 180.95]	74 W tungsten 183.84 [183.84, 183.84]	75 Re rhenium 186.21 [186.21, 186.21]	76 Os osmium 190.23(3)	77 Ir iridium 192.22 [192.22, 192.22]	78 Pt platinum 195.08 [195.08, 195.08]	79 Au gold 196.97 [196.97, 196.97]	80 Hg mercury 200.59 [200.59, 200.59]	81 Tl thallium 204.38 [204.38, 204.38]	82 Pb lead 207.2 [207.2, 207.2]	83 Bi bismuth 208.98 [208.98, 208.98]	84 Po polonium 209 [209, 209]	85 At astatine 210 [210, 210]	86 Rn radon 222 [222, 222]
87 Fr francium 223 [223, 223]	88 Ra radium 226 [226, 226]	89-103 actinoids	104 Rf rutherfordium 261 [261, 261]	105 Db dubnium 262 [262, 262]	106 Sg seaborgium 263 [263, 263]	107 Bh bohrium 264 [264, 264]	108 Hs hassium 265 [265, 265]	109 Mt meitnerium 266 [266, 266]	110 Ds darmstadtium 267 [267, 267]	111 Rg roentgenium 268 [268, 268]	112 Cn copernicium 269 [269, 269]	113 Nh nihonium 270 [270, 270]	114 Fl flerovium 271 [271, 271]	115 Mc moscovium 272 [272, 272]	116 Lv livermorium 273 [273, 273]	117 Ts tennessine 274 [274, 274]	118 Og oganesson 276 [276, 276]



57 La lanthanum 138.91 [138.91, 138.91]	58 Ce cerium 140.12 [140.12, 140.12]	59 Pr praseodymium 140.91 [140.91, 140.91]	60 Nd neodymium 144.24 [144.24, 144.24]	61 Pm promethium 145 [145, 145]	62 Sm samarium 150.36(2)	63 Eu europium 151.96 [151.96, 151.96]	64 Gd gadolinium 157.25(3)	65 Tb terbium 158.93 [158.93, 158.93]	66 Dy dysprosium 162.50 [162.50, 162.50]	67 Ho holmium 164.93 [164.93, 164.93]	68 Er erbium 167.26 [167.26, 167.26]	69 Tm thulium 168.93 [168.93, 168.93]	70 Yb ytterbium 173.05 [173.05, 173.05]	71 Lu lutetium 174.97 [174.97, 174.97]
89 Ac actinium 227 [227, 227]	90 Th thorium 232.04 [232.04, 232.04]	91 Pa protactinium 231.04 [231.04, 231.04]	92 U uranium 238.03 [238.03, 238.03]	93 Np neptunium 237 [237, 237]	94 Pu plutonium 244 [244, 244]	95 Am americium 243 [243, 243]	96 Cm curium 247 [247, 247]	97 Bk berkelium 247 [247, 247]	98 Cf californium 251 [251, 251]	99 Es einsteinium 252 [252, 252]	100 Fm fermium 257 [257, 257]	101 Md mendelevium 258 [258, 258]	102 No nobelium 259 [259, 259]	103 Lr lawrencium 260 [260, 260]

For notes and updates to this table, see www.iupac.org. This version is dated 28 November 2016. Copyright © 2016 IUPAC, the International Union of Pure and Applied Chemistry.

1. (24 points) 2-D and calculated 3-D structures for a molecule C_5H_9N is shown at the right. Carbon atoms are labeled numerically; the 3-D orientation is looking down the H-C2 bond vector.



a. Based on the structure, list the approximate atomic orbital hybridization of each of the following:

The methyl carbon: _____ Carbon 3: _____ The nitrogen: _____

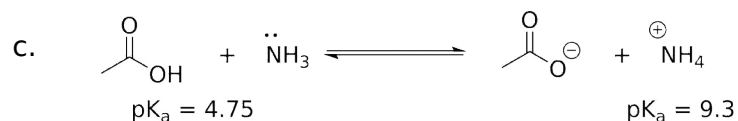
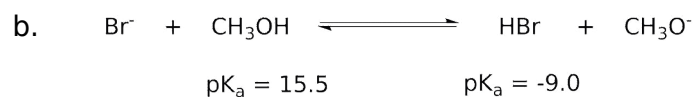
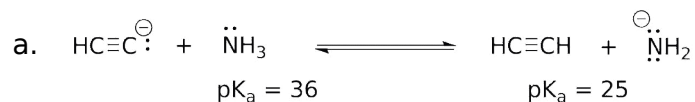
b. Draw two proper, complete resonance structures for this molecule.

c. Based on your answers above, describe the components of the C2-N bond in terms of bond type (sigma, pi). You may use any descriptions or drawings you wish.

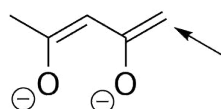
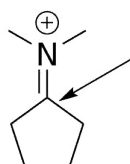
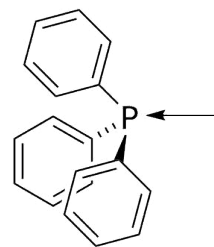
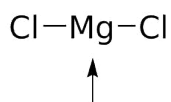
1. d. Based on the bond lengths shown below (and your prior answers) describe whether you think the C-N bonds in C_5H_9N are single, double or triple bonds and why.

<u>Compound</u>	<u>C-N Bond Length</u>
C2-N in C_5H_9N (shown above)	1.399 Å
C5-N in C_5H_9N (shown above)	1.473 Å
$CH_3CH_2-NH_2$	1.467 Å
$CH_3CH=NH$	1.266 Å
$CH_3C\equiv N$	1.149 Å

2. (9 points) Given the pK_a s of protonated species shown below, predict the magnitude of K_{eq} for each of the following reactions ($K_{eq} \gg 1$, $K_{eq} \ll 1$, or $K_{eq} \approx 1$)



3. (15 points) Identify each atom highlighted with an arrow in the structures below as either nucleophilic (N) or electrophilic (E). (Label each as N or E.)



4. (12 points) Draw structures for each of the following compounds.

a. n-Hexane

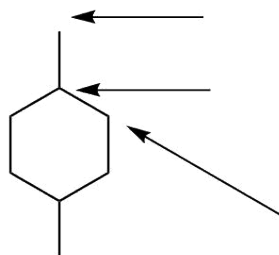
b. 3-methylheptane

c. 2-bromo-4-(1-propyl)nonane

5. (16 points) Using Newman projections, show the possible staggered rotamers of 3-methylpentane, looking down the C2-C3 bond. Rank them in order of stability. (Hint: draw 3-methylpentane and identify the bond down which you need to look.)

6. (24 points) Consider the free-radical halogenation of 1,4-dimethylcyclohexane (shown below in part a).

a. Label each of the different carbons as primary, secondary or tertiary.



b. Chlorination, as we know, is relatively nonselective. Draw all possible isomers for monochlorination of 1,4-dimethylcyclohexane (ignore cis/trans isomerism and other aspects of stereochemistry).

c. Bromination, on the other hand, tends to be more selective. Show the mechanistic propagation steps (including electron-pushing arrows) that illustrate selective formation of a single product from 1,4-dimethylcyclohexane.

Bond strengths (kcal/mol):

F-F	38
Cl-Cl	58
Br-Br	46
I-I	36
H-F	136
H-Cl	103
H-Br	87
H-I	71
CH ₃ -H	105
CH ₃ CH ₂ -H	101
(CH ₃) ₂ CH-H	98.5
(CH ₃) ₃ C-H	96.5
CH ₃ -F	110
CH ₃ -Cl	85
CH ₃ -Br	70
CH ₃ -I	57
CH ₃ CH ₂ -F	111
CH ₃ CH ₂ -Cl	84
CH ₃ CH ₂ -Br	70
CH ₃ CH ₂ -I	56
(CH ₃) ₂ CH-F	111
(CH ₃) ₂ CH-Cl	84
(CH ₃) ₂ CH-Br	71
(CH ₃) ₂ CH-I	56
(CH ₃) ₃ C-F	110
(CH ₃) ₃ C-Cl	85
(CH ₃) ₃ C-Br	71
(CH ₃) ₃ C-I	55