CH 233H

Second Midterm Exam Friday, May 13, 2016

Name_____KEY____

Please show your work for partial credit. If you need more space for an answer, use the back of the page and indicate where we should look.

You may not use notes or other materials with chemical information without the instructor's approval; necessary information is provided on pages at the back of the exam. Please do not use ipods or other music players.

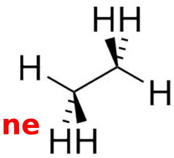
hydrogen 1 H 1.0079																		helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 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
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	unununium 111 Uuu [272]	ununbium 112 Uub [277]		ununquadium 114 Uuq [289]				

*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
* *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]

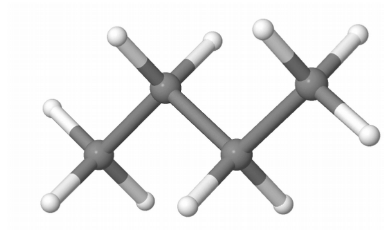
1. (15 points) Provide names for the following alkanes.

$CH_3CH_2CH_2CH_2CH_3$

Pentane



Ethane



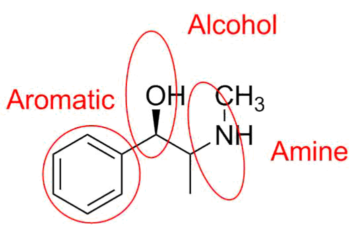
Butane

Decane

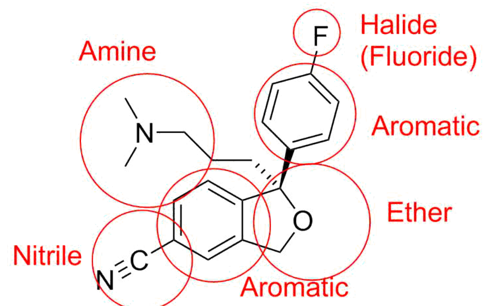
C_3H_8

Propane

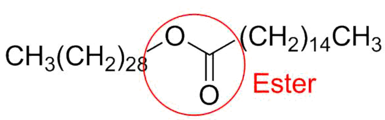
2. (10 points) Identify functional groups present in each of the following molecules. Circle the group and provide a functional group name.



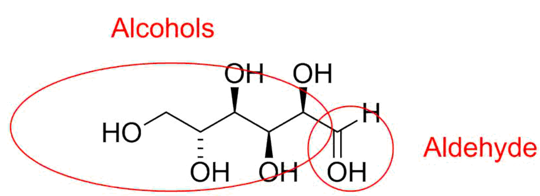
Ephedrine (a decongestant)



Citalopram (Celexa)
An antidepressant

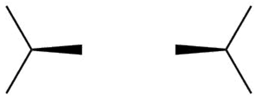


Triicontanyl palmitate
A component of beeswax

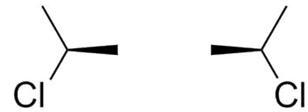


Glucose

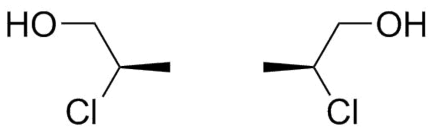
3. (12 points) Identify whether each of the following pairs of molecules are identical, constitutional isomers, stereoisomers, or unrelated.



Identical

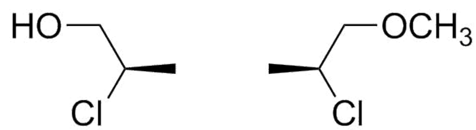


Identical



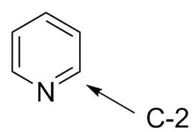
Stereoisomers

Constitutional Isomers



Unrelated (different Molecular Formulae)

4. (33 points) Understanding the chemistry of pyridine (C_5H_5N) requires understanding its bonding.



Pyridine (C_5H_5N)

A. If we consider C-2 (one of the carbons bonded to N), describe its geometry, and how will its valence atomic orbitals be hybridized for bonding?

Trigonal geometry (an implied H is present) and therefore sp^2. One unhybridized p orbital (perpendicular to the molecular plane) will be available for pi bonding.

B. Describe the sigma (σ) component of the C-N bond in terms of which valence atomic orbitals or hybrid orbitals will overlap to form the bonding interaction (use words or any pictures you wish).

Both C and N will be sp^2 hybridized, so the sigma bond will be the overlap of an sp^2 hybrid atomic orbital from each atom.

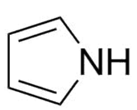
C. Describe the pi (π) component of the C-N bond in terms of which valence atomic orbitals or hybrid orbitals will overlap to form a bonding interaction.

Since each atom will have an unhybridized p prbital perpendicular to the plane of the molecule, these will overlap to form a pi interaction.

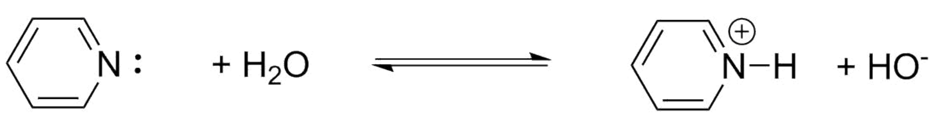
D. How would you describe the lone pair on nitrogen in a molecular orbital description? (What kind of MO does it occupy, and where in space is it pointed?)

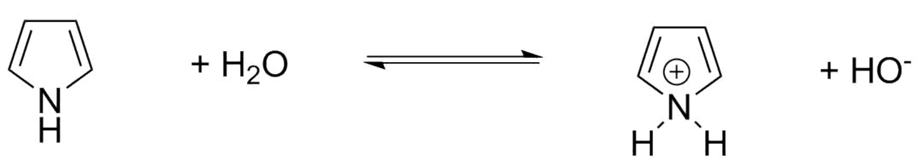
The lone pair will occupy an sp^2 hybrid lying in the plane of the molecule.

E. Another molecule, pyrrole (C_4H_5N) would at first glance appear to be similar to pyridine but is in fact quite different. Pyridine is a moderately strong base (pK_b = 8.79) while pyrrole is an extremely weak base (pK_b = 17.8). Suggest a bonding interaction in pyrrole that will change its reactivity and make it less basic.(HINT: Write out the two reactions you need to compare, and draw correct Lewis structures for each compound that account for any lone pairs of electrons.)



Pyrrole





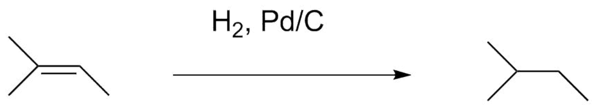
When pyridine is protonated, we can draw resonance structures that delocalize the charge. Because the lone pair being protonated is perpendicular to the delocalized pi system, protonation does not change the aromaticity of the molecule.

In pyrrole, however, protonation removes the lone pair that, when shared with the double bond electrons, made the molecule aromatic. There are no additional resonance structures possible to stablize the positive charge. The protonated form is thus highly disfavored, shifting equilibrium to the left.

5. (30 points) Classify the following reactions as one of:

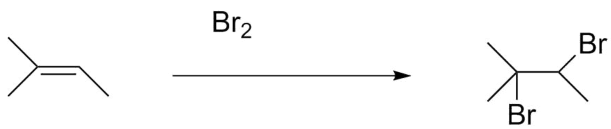
-Addition
-Substitution
-Elimination
-Condensation
-Hydrolysis
-Oxidation
-Reduction
-Acid/Base

a.



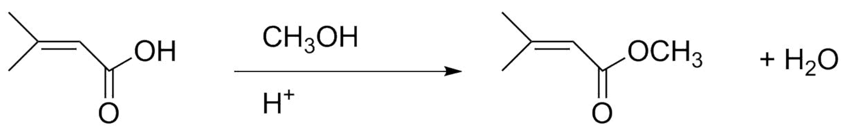
Addition or Reduction

b.



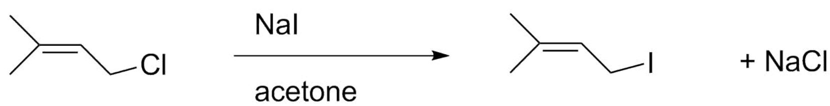
Addition or Oxidation

c.



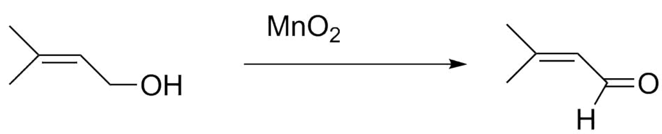
Condensation

d.



Substitution

e.



Oxidation

f.

Selected data that may be of use:

Physical constants:

$g = 9.8$ m/s^2	Gravitational Constant
$\varepsilon_0 = 8.85419 \times 10^{-12}$ $C^2/(Nm^2)$	Electric susceptibility of a vacuum
$c = 2.99792458 \times 10^{10}$ cm/s	Speed of light
R = 0.08206 L-atm/(mol-K) = 8.314 J/(mol-K)	Gas constant
$N = 6.022 \times 10^{23}$	Avogadro's Number
$k = 1.381 \times 10^{-23}$ $m^2kg/(K\text{-}s^2)$	Boltzmann constant
$h = 6.626 \times 10^{-34}$ m^2kg/s	Planck's constant
F = 96485 C/mol	Faraday's constant
$\pi = 3.14159$	
e = 2.71828	

Properties of State

Species	ΔH°_f	S°
N_2 (g)	0 kJ/mol	191.6 J/(mol-K)
O_2 (g)	0 kJ/mol	205.1 J/(mol-K)
NO (g)	90.25 kJ/mol	210.8 J/(mol-K)
C (s) (graphite)	0 kJ/mol	5.74 J/(mol-K)
C_2H_2 (g)	226.7 kJ/mol	200.9 J/(mol-K)
C_6H_6 (g)	82.6 kJ/mol	269.3 J/(mol-K)
CO_2 (g)	-393.5 kJ/mol	213.7 J/(mol-K)
Ag (s)	0 kJ/mol	42.55 J/(mol-K)
Ag^+ (aq)	105.6 kJ/mol	72.68 J/(mol-K)
K^+(aq)	-254.4 kJ/mol	102.5 J/(mol-K)
Zn (s)	0 kJ/mol	41.63 J/(mol-K)
Zn^{+2} (aq)	-153.9 kJ/mol	112.1 J/(mol-K)
Li (s)	0 kJ/mol	29.12 J/(mol-K)
Li_2O (s)	-595.8 kJ/mol	37.89 J/(mol-K)
Cu (s)	0 kJ/mol	33.15 J/(mol-K)
Cu_2O (s)	-170 kJ/mol	93 J/(mol-K)

Electromotive series:

TABLE 20.1 Some Selected Standard Electrode (Reduction) Potentials at 25 °C

Reduction Half-Reaction	$E°$, V
Acidic solution	
$F_2(g) + 2e^- \longrightarrow 2F^-(aq)$	+2.866
$O_3(g) + 2H^+(aq) + 2e^- \longrightarrow O_2(g) + H_2O(l)$	+2.075
$S_2O_8^{2-}(aq) + 2e^- \longrightarrow 2SO_4^{2-}(aq)$	+2.01
$H_2O_2(aq) + 2H^+(aq) + 2e^- \longrightarrow 2H_2O(l)$	+1.763
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.51
$PbO_2(s) + 4H^+(aq) + 2e^- \longrightarrow Pb^{2+}(aq) + 2H_2O(l)$	+1.455
$Cl_2(g) + 2e^- \longrightarrow 2Cl^-(aq)$	+1.358
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$	+1.33
$MnO_2(s) + 4H^+(aq) + 2e^- \longrightarrow Mn^{2+}(aq) + 2H_2O(l)$	+1.23
$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(l)$	+1.229
$2IO_3^-(aq) + 12H^+(aq) + 10e^- \longrightarrow I_2(s) + 6H_2O(l)$	+1.20
$Br_2(l) + 2e^- \longrightarrow 2Br^-(aq)$	+1.065
$NO_3^-(aq) + 4H^+(aq) + 3e^- \longrightarrow NO(g) + 2H_2O(l)$	+0.956
$Ag^+(aq) + e^- \longrightarrow Ag(s)$	+0.800
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$	+0.771
$O_2(g) + 2H^+(aq) + 2e^- \longrightarrow H_2O_2(aq)$	+0.695
$I_2(s) + 2e^- \longrightarrow 2I^-(aq)$	+0.535
$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$	+0.340
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \longrightarrow 2H_2O(l) + SO_2(g)$	+0.17
$Sn^{4+}(aq) + 2e^- \longrightarrow Sn^{2+}(aq)$	+0.154
$S(s) + 2H^+(aq) + 2e^- \longrightarrow H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \longrightarrow H_2(g)$	0
$Pb^{2+}(aq) + 2e^- \longrightarrow Pb(s)$	−0.125
$Sn^{2+}(aq) + 2e^- \longrightarrow Sn(s)$	−0.137
$Fe^{2+}(aq) + 2e^- \longrightarrow Fe(s)$	−0.440
$Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$	−0.763
$Al^{3+}(aq) + 3e^- \longrightarrow Al(s)$	−1.676
$Mg^{2+}(aq) + 2e^- \longrightarrow Mg(s)$	−2.356
$Na^+(aq) + e^- \longrightarrow Na(s)$	−2.713
$Ca^{2+}(aq) + 2e^- \longrightarrow Ca(s)$	−2.84
$K^+(aq) + e^- \longrightarrow K(s)$	−2.924
$Li^+(aq) + e^- \longrightarrow Li(s)$	−3.040
Basic solution	
$O_3(g) + H_2O(l) + 2e^- \longrightarrow O_2(g) + 2OH^-(aq)$	+1.246
$OCl^-(aq) + H_2O(l) + 2e^- \longrightarrow Cl^-(aq) + 2OH^-(aq)$	+0.890
$O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$	+0.401
$2H_2O(l) + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$	−0.828