Chemistry 221 Hour exam 2
Department of Chemistry, Oregon State University

Name EXAM KEY

8 July 2010

$$\Delta H_{rx} \simeq \sum_{bonds\ broken} D_i - \sum_{bonds\ formed} D_i$$

$$F(formal\ charge) = number\ valence\ electrons - (bonds\ from\ atom + nonbonded\ electrons)$$

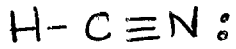
Molecular shapes predicted by VSEPR theory

Note that one electron *pair* in the present context may denote a double or triple bond.

Number of electron pairs (domains)	electronic geometry	Number of unshared pairs	molecular geometry
2	linear	0	linear
3	triangular planar	0	triangular planar
		1	bent
4	tetrahedral	0	tetrahedral
		1	triangular pyramid
		2	bent
5	triangular bipyramidal	0	triangular bipyramidal
		1	see-saw
		2	T-shaped
		3	linear
6	octahedral	0	octahedral
		1	square pyramidal
		2	square planar

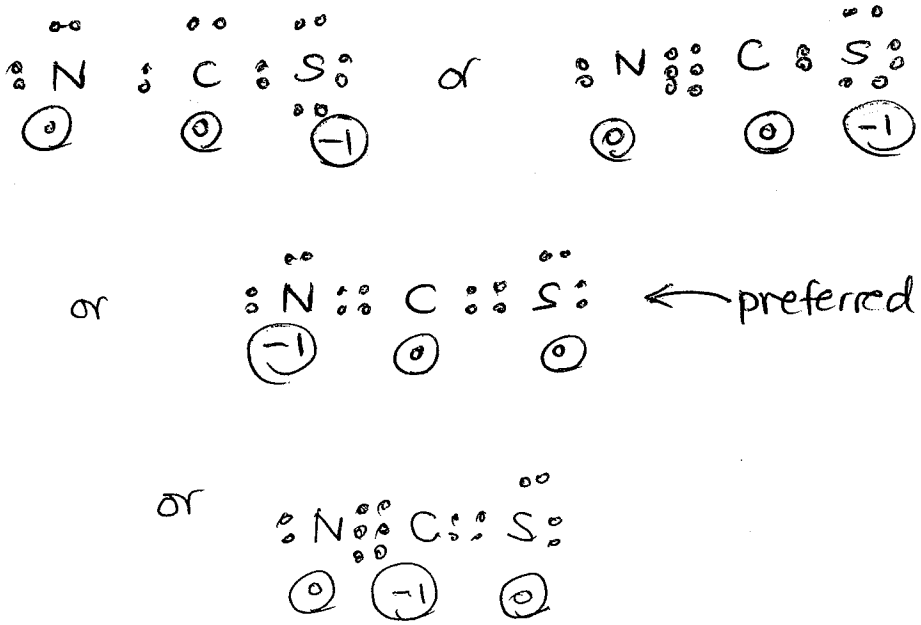
1. (16 pts) Draw the Lewis structures of NF_3, and HCN.

8



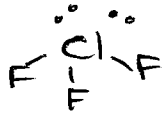
8

2. (16 pts) Draw three Lewis structures of the thiocyanate ion, NCS^- assigning formal charges to each. Select the preferred structure according to the dictates of formal charge and electronegativity differences. Nitrogen is the most electronegative element among the three.

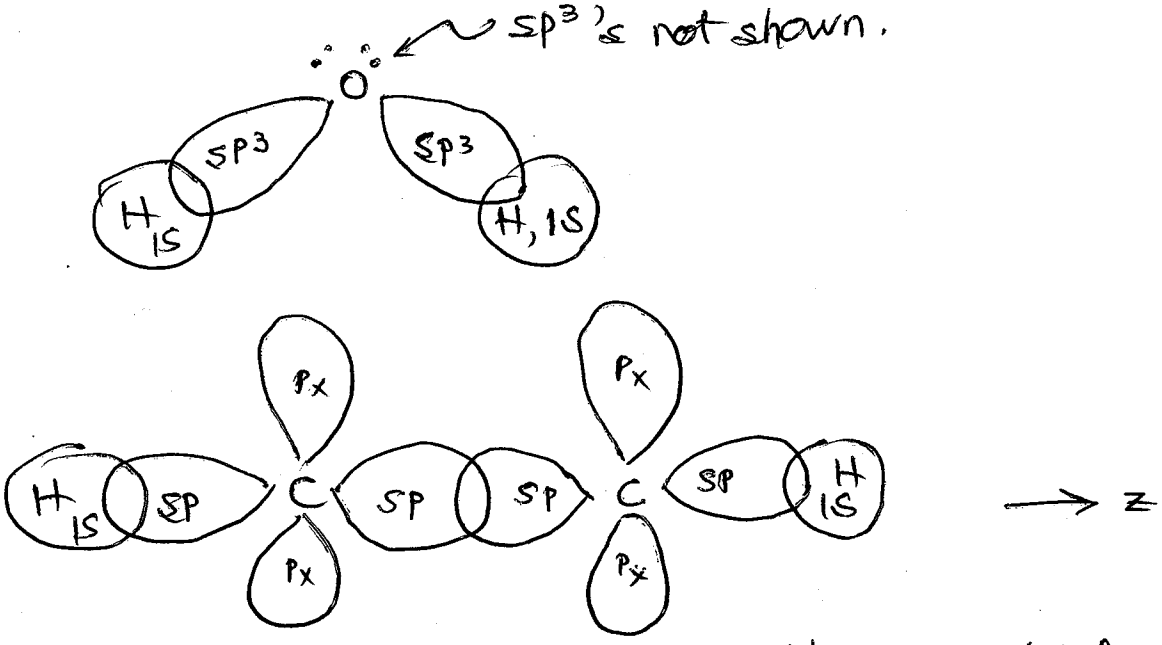


3. (12 pts) Complete the table using VSEPR and hybridization theory,

molecule	number of electron pairs	molecular geometry	hybridization
O_3	3	bent	sp^2
$[SnCl_3]^-$	4	triangular pyramid	sp^3
ClF_3	5	T-shape	dsp^3
XeF_4	6	square planar	d^2sp^3



4. (16 pts) Construct a pictorial representation of the valence bond theory prediction of bonding in H_2O and $H-C\equiv C-H$ using hybrid orbitals.



the py-orbitals point out of plane and overlap to form π-bonds

5. (16 pts) Suppose that the second row diatomics have molecular orbitals whose energies increase as

$$\sigma_{2s} < \sigma^*_{2s} < \pi_{2px}, \pi_{2py} < \sigma_{2pz} < \pi^*_{2px}, \pi^*_{2py} < \sigma^*_{2pz} \tag{1}$$

Arrange following molecules,

b

OF	N_2	O_2	O_2^-	F_2
1.5	3	2	1.5	1

(2)

in the order of

(a) increasing bond order (smallest to largest)

$F_2 < O_2^-, OF < O_2 < N_2$

(b) increasing bond length

$N_2 < O_2 < O_2^-, OF < F_2$

(c) diamagnetic to paramagnetic character

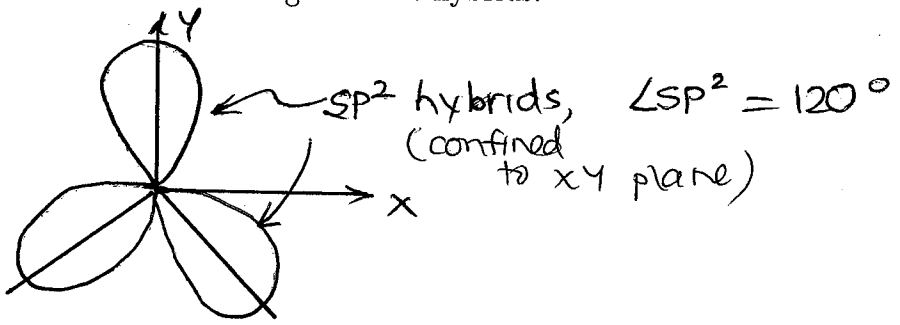
$F_2, N_2 < O_2^-, OF < O_2$

(d) increasing number of anti-bonding electrons

$N_2 < O_2 < O_2^-, OF < F_2$

16

6. (8 pts) Draw each member of the set of sp^2 hybrids using an x, y, z coordinate system and indicate relative angles of the hybrids.



7. (8 pts) In the photo-electron spectrum of O_2,

   (a) the electron ejected by the lowest energy photon, i.e., the least bound electron, has the following orbital designation:

$$\pi^*_{2p_x} \text{ or } \pi^*_{2p_y}$$

   (b) and, if the kinetic energy of the outgoing electron is 2 ev and the binding energy of the electron to O_2 is 16 ev, what is the wavelength (in nm) of the radiation responsible for electron ejection. 1 $ev = 1.6 \times 10^{-19}$J, $h = 6.6 \times 10^{-34}$ J s, $c = 3 \times 10^8$m/s

$$h\nu = \frac{hc}{\lambda} = E_b + E_K = (16+2)\,ev \times 1.6\,\frac{J}{ev} \times 10^{-19}$$

$$\lambda = \frac{hc}{E_b + E_K} = \frac{(6.6 \times 10^{-34}\,J\cdot s)(3 \times 10^8\,m/s)}{18 \times 1.6 \times 10^{-19}\,J}$$

$$\lambda = 6.9 \times 10^{-8}\,m = 69\,nm$$