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

Name EXAM KEY

8 July 2009

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

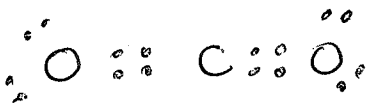
$$F(formal\ charge) = number\ valence\ electrons - (bonds\ from\ atom + nonbonded\ electrons)$$

Molecular shapes predicted by VSEPR theory

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

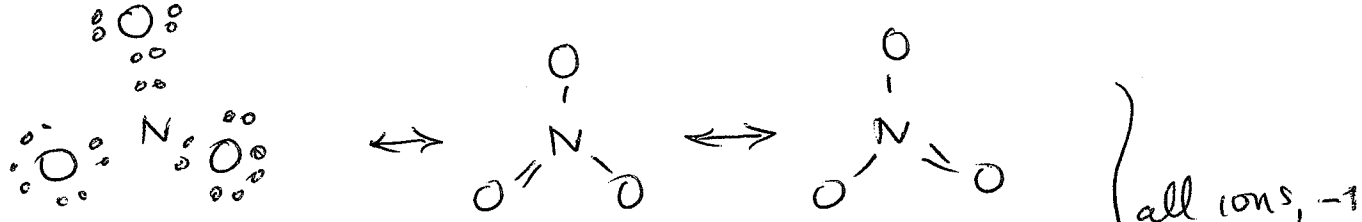
Number of electron pairs (domains)	electronic geometry	Number of unshared pairs	molecular geometry
2	linear	0	linear
3	triangular planar	0	triangular planar
		1	bent
4	tetrahedral	0	tetrahedral
		1	triangular pyramid
		2	bent
5	triangular bipyramidal	0	triangular bipyramidal
		1	see-saw
		2	T-shaped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

1. (16 pts) Draw the Lewis structures of CO_2, and O_3.

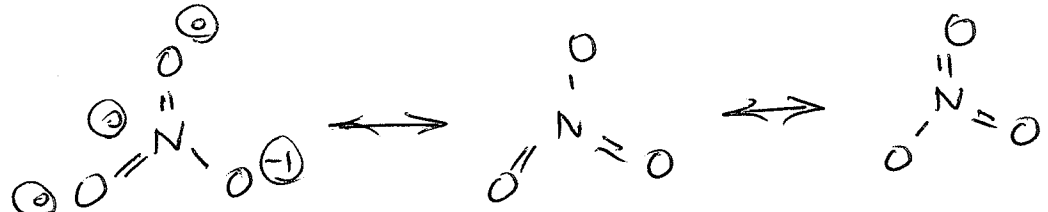


2. (16 pts) Draw two Lewis structures of the nitrate ion, one in accord with the octet rule, and the second, according to the dictates of formal charge and electronegativity differences. Include resonance structure if appropriate.

a)



b)



Formal charges violates octet rule

-10 structures

-3 charges

-5 resonance

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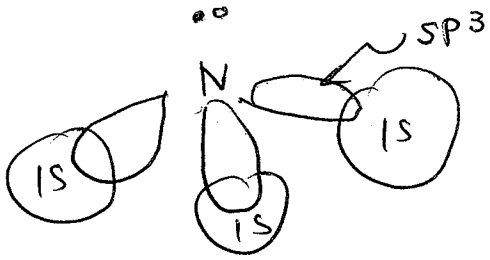
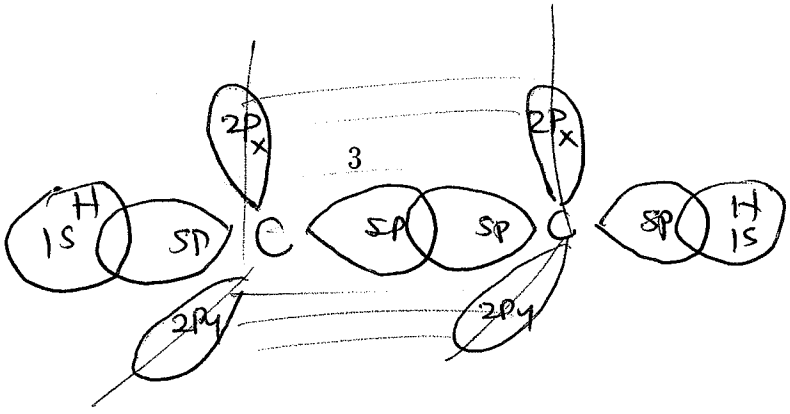
3. (12 pts) Complete the table using VSEPR and hybridization theory,

molecule	number of electron pairs	molecular geometry	hybridization
CO_2	2	linear	sp
CH_3Cl	4	tetrahedral	sp^3
IF_3	5	t-shape	dsp^3
XeF_4	6	octahedral	d^2sp^3

4. (16 pts) Construct a pictorial representation of the valence bond theory prediction of bonding in NH_3 and $H - C \equiv C - H$ using hybrid orbitals.





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

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

For the following molecules,

3	2	2.5	1	2.5
N_2	O_2	NO	F_2	C_2^-

(2)

arrange in order corresponding to

(a) increasing bond order (smallest to largest)

$F_2 < O_2 < NO = C_2^- < N_2$

(b) increasing bond length

$N_2 < NO = C_2^- < O_2 < F_2$

(c) diamagnetic to paramagnetic

$N_2, F_2 < NO, C_2^- < O_2$

(d) increasing number of anti-bonding electrons

$N_2 = C_2^- < NO < O_2 < F_2$

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6. (6 pts) Why do we not have sp^4 hybrids?

There are only 3 p orbitals.

7. (6 pts) In the N_2^- molecular ion, the photo-electron that is ejected by the lowest energy photon resides in a molecular orbital with the following designation:

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

8. (12 pts) Calculate ΔH_{rxn} for

$$H_3C - CH_2 - CH_3 + 7O_2 \rightarrow 3CO_2 + 8H_2O \qquad \textit{balanced incorrectly}$$

$$H_3C - CH_2 - CH_3 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

Bond dissociation energies, in units of kJ/mol, are $D_{C-H} = 413, D_{C-C} = 348, D_{O-H} = 463, D_{C-O} = 358, D_{C=O} = 799, D_{O=O} = 495$

ΔH_{rxn} = broken − formed

$= 8D_{C-H} + 2D_{C-C} + 7D_{O=O} - [6D_{C=O} + 16D_{O-H}]$

$= 8(413) + 2(348) + 7(495) - [6(799) + 16(463)]$

$= -4737$ kJ/mol

answer consistent with unbalanced eqn.