INORGANIC CHEMISTRY - 2nd HOURLY EXAM

November 9 1998

Name Key

1. For the following molecules and ions, [35 pts]

   i) Write the correct Lewis structure showing all formal charges
   ii) Sketch and identify the correct molecular geometry. Determine all "idealized" bond angles
   iii) Determine the idealized hybridization of all sigma bonding orbitals on the central atom

A.) ICl_5

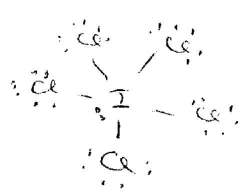
I) 7e

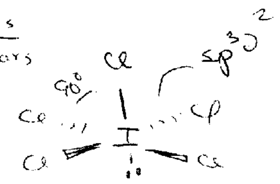
Cl) 7e × 5 = 35e⁻

42e = 21e pairs

− 5e pairs

16e pairs





square pyramidal

B.) SCN^-

S) 6e

C) 4e

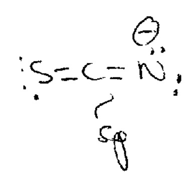
N) 5e

(−) 1e

16e = 8e pairs

− 2e pairs

6e pairs



linear

C.) PO_4^{3-}

P) 5e ~~pairs~~

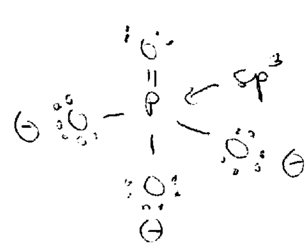
O) 6e ~~pr~~ × 4 = 24e

(−) 3e

32e = 16e pairs

− 4e pairs

12e pairs



tetrahedral

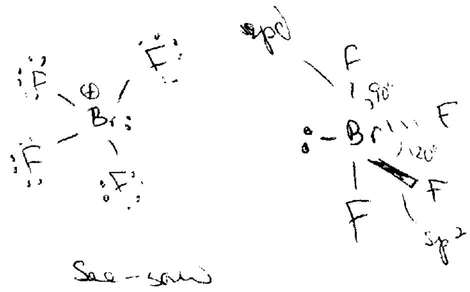
4 degenerate resonance forms

D.) BrF_4^-

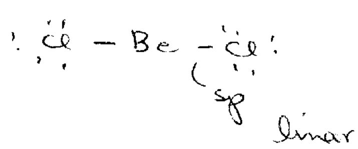
Br) 7e⁻
F) 4 × 7e⁻ = 28e⁻
Θ) − e⁻

34 e⁻ = 17 e⁻ pairs
−4 e⁻ pairs

13 e⁻ pairs



E.) $BeCl_2$



Be) 2e⁻
Cl) 2 × 7e⁻ = 14 e⁻

16 e⁻ = 8 e⁻ pairs
− 2 e⁻ pairs

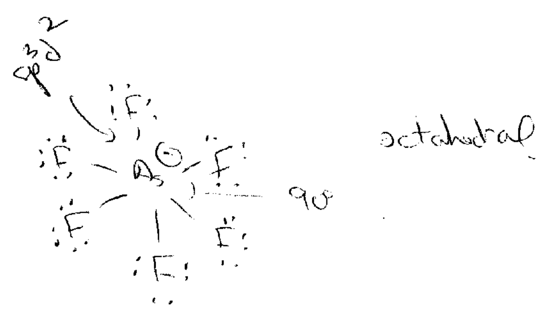
6 e⁻ pairs

F.) AsF_6^-

As) 5 e
F) 7e⁻ × 6 = 42 e⁻
Θ) 1 e⁻

48 e⁻ = 24 e⁻ pairs
− 6 e⁻ pairs

18 e⁻ pairs

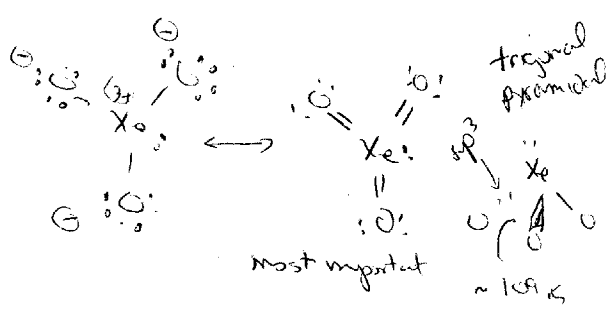


G.) XeO_3

Xe) 8 e⁻
O) 3 × 6e⁻ = 18 e⁻

26 e⁻ = 13 e⁻ pairs
− 3 e⁻ pairs

10 e⁻ pairs

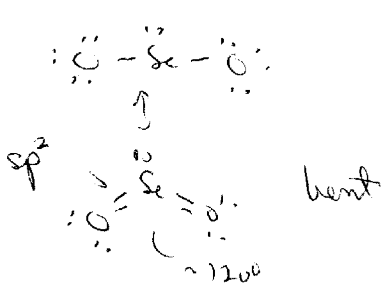


H.) SeO_2

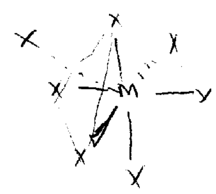
Se) 6e⁻
O) 6e⁻ × 2 = 12 e⁻

18 e⁻ = 9 e⁻ pairs
− 2 e⁻ pairs

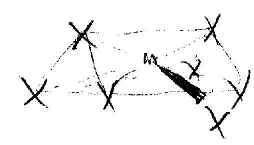
7 e⁻ pairs



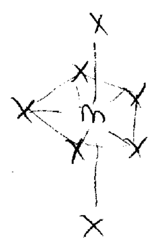
2. There exists three common geometries for molecules, MX_7, containing only 7 bonding electron pairs on the central atom. For each of the three geometries, give the correct name of the geometry and draw the geometry *clearly* indicating the position of the central atom and the seven terminal atoms. [12 pts]



mono capped octahedron



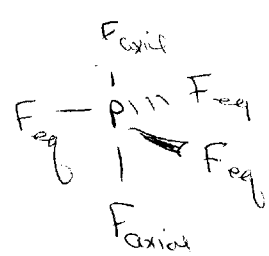
monocapped trigonal bipyramid



pentagonal bipyramid

3. The following questions pertain to the trigonal bipyramid geometry such as exhibited by PF_5.

A.) Draw the trigonal bipyramidal structure and clearly label those positions which are *axial* and *equatorial*. [4pts]



B.) What is the nominal hybridization of the hybrid orbitals to the *axial* and to the *equatorial* atoms. [5 pts]

P - F axial = pd

P - F eq = sp^2

C.) The axial and equatorial bonds show different properties. For the molecule PF_5, show how the following properties differ between the axial and equatorial P-F bonds, and explain why they differ in the way they do.

I) bond length [3 pts]

axial is longer – less s character

II) bond strength [3 pts]

axial is weaker – less s character

III) magnitude of ^{1}J(P-F) coupling constant [3 pts]

axial is lower in magnitude – less s character

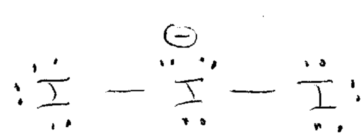
IV) the tendency of electronegative substituents to prefer these bonds [3 pts]

axial sites are preferred by electronegative substituents – more p character (Bent's rules)

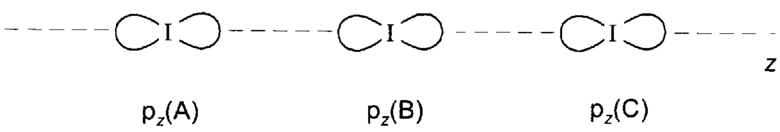
4. Consider the linear triatomic ion, I_3^-.

A.) Draw a Lewis structure for I_3^-. [5 pts]

I) 7e⁻ × 3 = 21e⁻
θ) 1e⁻
22e⁻ = 11 e⁻ pairs
− 2 e⁻ pairs
9 e⁻ pairs



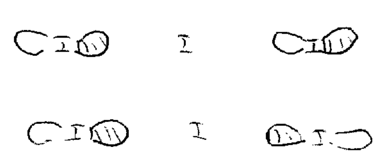
B.) The rest of the problem will consider a molecular orbital diagram for I_3^- showing σ bonding only. Assume that the σ bonding interactions occur only between the p_z orbitals of the individual iodine atoms. Use *qualitative* symmetry arguments in your answer (a character table is not necessary).



I What is the functional form for the symmetry adapted linear combinations (SALC's) for the the p_z orbitals of the terminal iodine atoms? Sketch these combinations. [5 pts]

$\Psi_1 = p_z(A) + p_z(C)$

$\Psi_2 = p_z(A) - p_z(C)$



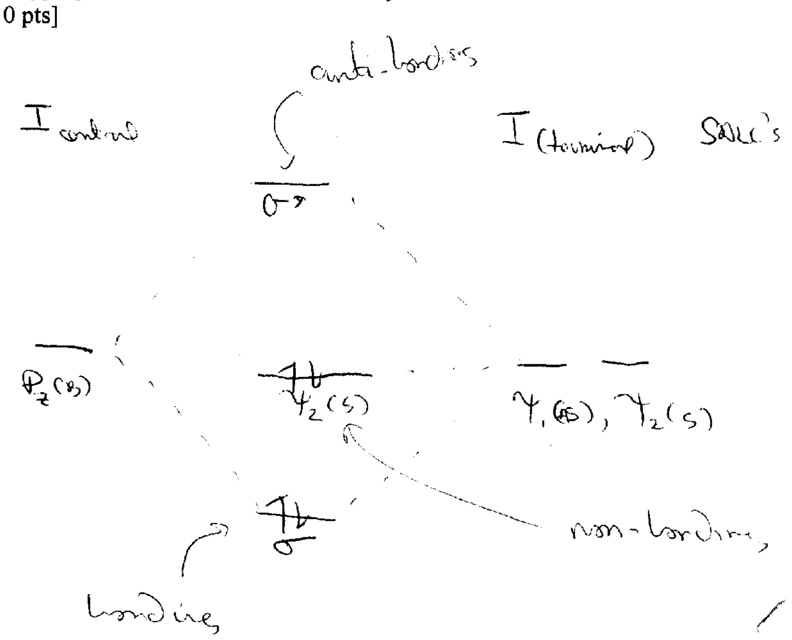
II What are the symmetry properties of these SALC's relative to the σ_h mirror plane (*i.e.* symmetric or antisymmetric)? What is the symmetry property of the p_z orbital of the *central* iodine atom in respect to the σ_h operation? [6 pts]

$\Psi_1 \Rightarrow$ anti-symmetric

$\Psi_2 \Rightarrow$ symmetric

$p_z(B) \Rightarrow$ antisymmetric

III Construct a molecular orbital diagram describing σ bonding for I_3^-. Be sure to label molecular orbitals as bonding, non-bonding, or antibonding. Place the appropriate number of electrons into your molecular orbital scheme. [10 pts]



IV What is the total bond order for σ bonding in this ion? What is the bond order for each individual I-I bond? [4 pts]

$B.O. = \frac{1}{2}(2) = 1$

$\frac{B.O.}{\text{I-I bond}} = \frac{1}{2}$