CH301H – Principles of Chemistry I› Honors
Fall 2012, Unique 51390

Exam 1
27 September 2012

Name: Key

You may use your textbook and a calculator for arithmetic.

Honor Code:

"The core values of the University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community."

I certify that the work on this exam is entirely my own.

Signature Date

1. (21 points) True / False. Indicate whether each of the following statements are true, false, or if there is no way to know (NWTK) from the information given.

a. True (False) NWTK Mass is an intensive property.

b. (True) False NWTK If an electron is added to an atom with a measurable electron affinity, the potential energy of the anion is always lower than the individual atom and electron.

c. True (False) NWTK Fluorine has the largest ionization energy of any atom in the periodic table.

d. True (False) NWTK All molecules containing a halide have a permanent net dipole moment.

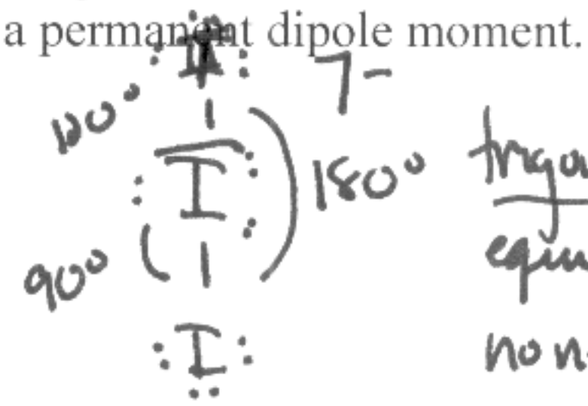
e. True (False) NWTK Electrons in the outermost shell of any atom have the largest ionization energies.

f. True (False) NWTK Resonance structures represent distinct configurations of bonds and lone pairs in which a molecule may be found.

g. True (False) NWTK The following molecules are ranked in order of increasing dipole moment: HF < HCl < HBr < HI

2. (20 points) For each of the following molecules, draw the correct Lewis dot structure, predict the molecular geometry, estimate the angles between bonds and lone pairs around each atom, and determine whether the molecule has a permanent dipole moment.

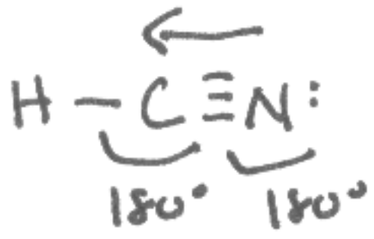
a) I_3^-



trigonal bipyramidal - e⁻ in equatorial spots

no net dipole

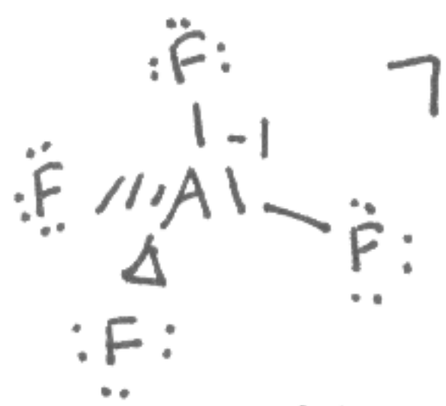
b) HCN



linear

dipole moment

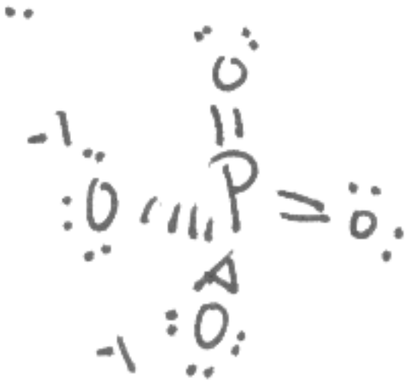
c) AlF_4^-



tetrahedral, 109.5° for each bond angle

no net dipole

d) PO_4^{2-}



+ resonance structures

- tetrahedral - 109.5

- no net dipole

3. (20 points) One of the molecules from the previous question, HCN, has a permanent dipole moment of 4 D.

a) Redraw the molecule indicting the direction of the dipole moment.

$H-C\equiv N:$ ←

b) What is the percent ionic character of the bond responsible for this molecule's dipole moment?

estimate $r(C\equiv N)$ of 1.1 Å

$\delta = \frac{(0.2082\ \text{Å/D})\mu}{r} = \frac{(0.2082\ \text{Å/D})(4\text{D})}{1.1\ \text{Å}}$ $\delta = 0.76$

⇒ 76% ionic character

c) What is the partial charge on the two atoms involved in the bond described in part b)?

Assume partial charge evenly split between negative (N) and positive (C+H)

⇒ $\delta = -0.76$ on N

$\delta = +0.38$ on H, $+0.38$ on C

4. (25 points) Given the following data, determine the identity of X, Y, and Z. Clearly explain your reasoning.

Bond	Bond length (Å)	Bond Energy (kJ mol^{-1})
C-C	1.51	362
C-X	1.1	413
C-Y	1.45	308
C-Z	1.77	303

Bond length increases w/ decreasing bond energy and increasing atomic size

a) X: Shorter + higher E than C-C

⇒ X = H

b) Y: Y and Z have similar bond energies, but C-Z is considerably longer.

Assume Y + Z have similar electronegativity but Z is larger

Y = O

z) Z:

Z = Cl

5. (14 points) Determine the bond dissociation energy for ScCl, which has an equilibrium bond length of 2.73 Å.

1. Ionize Sc: $Sc \rightarrow Sc^+ + e^-$ $IE_1 = 6.54\ eV/atom$

$$6.54\ eV/atom \left(\frac{1.602\times10^{-19}\ J}{1\ eV}\right)\left(\frac{6.022\times10^{23}\ atom}{mol}\right) = \underline{6.31\times10^5\ J/mol}$$

2. Ionize Cl:

$Cl + e^- \rightarrow Cl^-$ $EA = 349\ kJ/mol = \underline{3.49\times10^5\ J/mol}$

But the energy liberated is the opposite of this:

$\underline{EA = -3.49\times10^5\ J/mol}$

3. $V_{bond} = \frac{q_1 q_2}{4\pi\varepsilon_0 r} = \underline{\frac{(+1)(-1)(1.602\times10^{-19}\ C)^2}{4\pi(8.854\times10^{-12}\ C^2/J\,m)(2.73\times10^{-10}\ m)}}$

$V_{bond} = -8.45\times10^{-19}\ J/atom\left(6.022\times10^{23}\ \frac{atom}{mol}\right)$

$\underline{V_{bond} = -5.09\times10^5\ J/mol}$

$Total = E_{in} + E_{out}$

$V_{TOTAL} = 6.31\times10^5\ J/mol + -3.49\times10^5\ J/mol + -5.09\times10^5\ J/mol$

$\boxed{V_{TOTAL} = -2.27\times10^5\ J/mol}$