Chemistry 211
Fall 2024
Test 4

Name: _____
Please Print

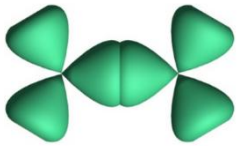
Multiple Choice: (4 points each. Put answers in left margin as capital letters.)

1. Which of the following is false?

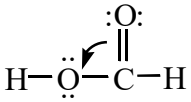
   A) The energy of any electron in a hydrogen atom depends only on n.
   B) A node (or nodal surface) is a place of zero electron density.
   C) In any atom, no two electrons may have the same four quantum numbers.
   D) The lowest energy state for an atom is its excited state.
   E) Effective nuclear charge is positive charge experienced by an electron in an atom/ion.

2. With respect to electronegativity values,

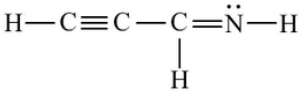
   A) S > O > Si B) O > S > Si C) Si > S > O D) Si > O > S E) S > Si > O

3. The graphic:  depicts a(n) _____ bond.

   A) *p-p* π B) *p-p* σ C) *sp* σ D) sp^2 σ E) *s-s* σ

4. What is the approximate bond angle for the indicated bond? 

   A) 45º B) 90º C) 109.5º D) 120º E) 180º

5. How many σ and π bonds, respectively, are in 

   A) 4, 2 B) 4, 3 C) 6, 2 D) 6, 3 E) 9, 0

6. Which of the following molecules is paramagnetic?

   A) BF_3 B) H_3PO_4 C) NO D) NaCl E) SF_6

7. Which of the following is **not** true of **valence** bond theory?

   A) Hybridized orbitals yield more stable bonds than atomic orbitals.
   B) π-Bonds occur between atomic orbitals, not hybrid orbitals.
   C) Bonds are the result of the overlap of atomic or hybrid orbitals.
   D) sp^2 Hybrid orbitals lie 120º apart.
   E) Anti-bonding orbitals are higher in energy than bonding orbitals.

8. Which of the following hybridization schemes is normally involved in a carbon-carbon double bond?

A) *sp* B) sp^2 C) sp^3 D) sp^3d E) sp^3d^2

Discussion Questions: (You must show your work to receive credit.)

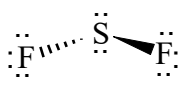
1. A minimum energy of 498 kJ/mol is required to break the bond in O_2. What wavelength of light is required to break the bond in a molecule of oxygen? Is this the minimum or maximum wavelength necessary? Explain. (10 points)

$$\nu = \frac{E}{h} = \frac{\left(\frac{498\ kJ}{mol}\right)\left(\frac{1000\ J}{kJ}\right)\left(\frac{1\ mol}{6.022 \times 10^{23}\ molecules}\right)}{6.626 \times 10^{-34}\ J\cdot s} = 1.24 \times 10^{15}\ s^{-1}$$

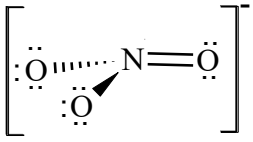
$$\lambda = \left(\frac{1}{1.24 \times 10^{15}\ s^{-1}}\right)\left(\frac{2.998 \times 10^{8}\ m}{s}\right) = 2.40 \times 10^{-7}\ m$$

Maximum. Frequency and wavelength are inversely proportional. Frequency and energy are directly proportional, so a minimum energy means minimum frequency, which means maximum wavelength.

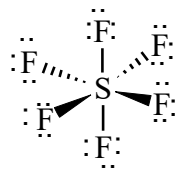
2. For each of the following molecules: 1) draw the correct Lewis structure, 2) what is the actual (molecular) shape, 3) what is the hybridization of the underlined atom and 4) write "polar" or "nonpolar" to indicate which is true of the first 2 species: $\underline{S}F_2$, $\underline{N}O_3^-$, and $\underline{S}F_6$. (26 points)



bent
sp^3
polar



trigonal planar
sp^2



octahedral
sp^3d^2
nonpolar

3. Place the isoelectronic ionic compounds, CaO, KF, ScN, in order of increasing lattice energy and justify the order you chose. (5 points)

KF < CaO < ScN. The relationship between ions in a lattice is largely given by the formula:

$$E = k\frac{Q_1Q_2}{d}$$

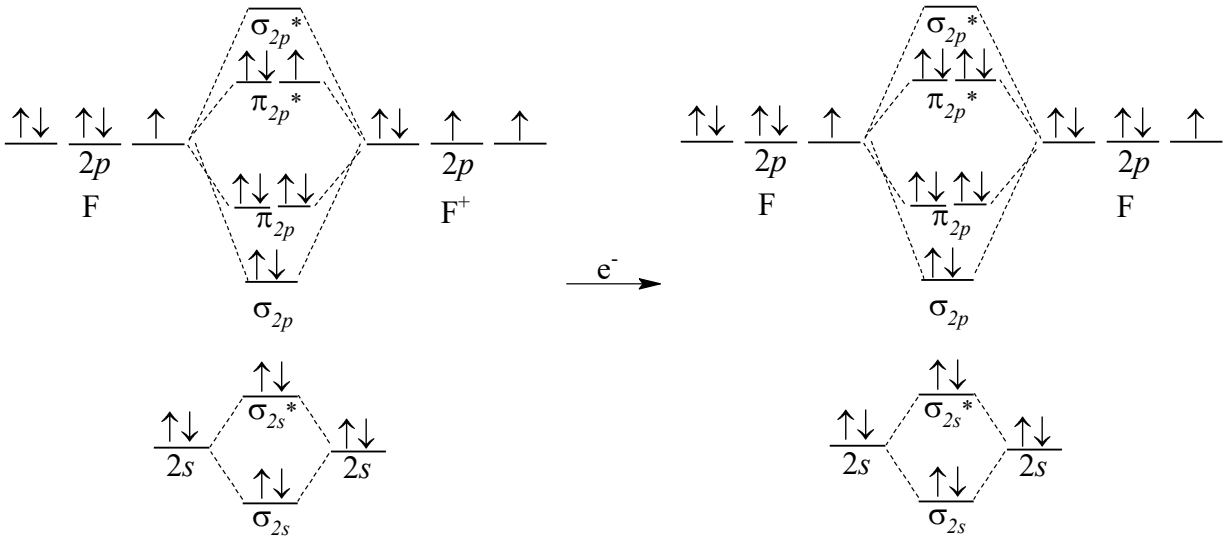
where Q_1 and Q_2 are the whole number charges on the ions and d is the distance of separation.

The charges on the ions in KF are ±1, on the ions in CaO ±2, and on the ions in ScN ±3. If the interionic distances ("d" above) are the approximately same, then the energy of attraction in CaO should be 4 times that in KF, while the corresponding energy in ScN should be 9 times larger. (In reality, the actual values are amazing close to the calculated values, but a little larger suggesting that the ions in the more highly charged salts are also separated by a slightly smaller distance than the ions in KF (which is true).)

4. Which is stronger a *p-p* σ-bond or π-bond? Explain why using <u>valence bond (VB) theory</u>. (10 points)

   σ bond. In VB theory, bonds result from the overlap of orbitals. Sigma bonds result from the end-to-end overlap of orbitals, while π-bonds result from side-to-side overlap. In general, end-to-end overlap yields the larger overlap volume and so results in stronger bonds. Also, π-bonds have a node whereas σ-bonds don't, which increases their energy.

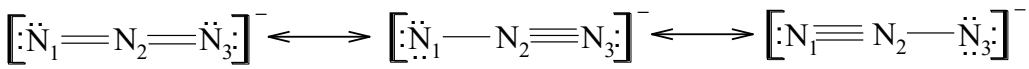
5. Write out the molecular orbital diagram for F_2^+. Show only the n = 2 energy level. Would adding an electron increase or decrease the bond length and why? (12 points)



B.O. (F_2^+) = ½(8 – 5) = 1.5 B.O. (F_2) = ½(8 – 6) = 1

The bond length lengthens because the bond order decreases from 1.5 to 1.

6. Draw the 3 possible resonance structures for N_3^-. For one of the structures, provide the formal charges on each atom and show the structural technique for assigning formal charge or provide the equation for the calculations. (5 points)



FC_{N1} =	-1	-2	0
FC_{N2} =	+1	+1	+1
FC_{N3} =	-1	0	-2

$FC_{N1} = 5 - 2 - 4 = -1$ $FC_{N2} = 5 - 4 - 0 = +1$ $FC_{N3} = 5 - 2 - 4 = -1$