Chemistry 141 Problem Session # 3
Tro Chapters 8,9,10
Fall 2009

1. What is the frequency of an X ray with a wavelength of 1.5×10^{-2} nm? What is the energy, in joules, associated with a photon of this frequency? What would be the energy of a mole of such photons?

2. One way to gain information about the origin and functions of stars within the universe is to study the origin and distribution of the hundreds of gamma ray sources in the sky. If one such source were producing high-energy gamma rays of 1.6×10^{-8}J, what wavelength would astronomers have detected? What is the frequency of this radiation?

3. A photon with a wavelength of 415 nm strikes a metal surface ejecting an electron with a velocity of 9.0×10^{5} m/sec. What is the threshold frequency of the metal? (kinetic energy = $^{1}/_{2}mv^{2}$, J = kg $\cdot$ m^{2}/sec^{2})

4. Taking a photograph of a moving object – for example, a person sprinting—will cause some blurring or the actual person's position when the photograph is developed. Therefore, the more blur, the better you represent movement. If the entire scene were re-shot using a faster shutter speed, what information would you gain and what would you lose in the photo?

5. Consider the following levels of a hypothetical atom:

E_∞ ____________ 0 J

E_4 ____________ -1.0×10^{-19}

E_3 ____________ -5.0×10^{-19}

E_2 ____________ -10×10^{-19}

E_1 ____________ -15×10^{-19}

a. An electron in the E_1 energy level will jump to a higher energy level when excited by light with a wavelength of 190 nm. Calculate the energy of the light beam.

b. Predict the energy level to which the electron will jump upon excitation by 190 nm light.

c. How many different emission lines would you predict as electrons fall from the E_4 state back to the ground state by all possible routes? (Draw the possible transitions on the diagram using arrows.)

6. When an electron is in the fifth energy level, how many sublevels are possible? How many orbitals are possible?

7. If the four quantum numbers for an electron were (3,2,1,+½) what would be the four quantum numbers for an electron in the same orbital as the first electron?

8. The sequence in each line that follows represents values for the quantum numbers for an electron in a hydrogen atom. Select any sequence(s) that are not possible and explain the problem(s)?

n	l	m_l	
3	-1	0	
2	+2	+1	
3	+2	+3	
1	+1	+1	
4	+3	-2	

9. Define the following terms:
   a. octet rule
   b. antibonding molecular orbital
   c. delocalization
   d. bond angle
   e. bonding electron pair
   f. bond length
   g. bond order
   h. covalent bond
   i. electronegativity
   j. formal charge
   k. hybrid atomic
   l. Lewis structure
   m. lone pair electrons
   n. molecular orbital theory
   o. pi bond
   p. polar covalent bond
   q. resonance hybrid
   r. sigma bond
   s. Coordinate covalent bond
   t. electron affinity
   u. valence bond theory

10. Write the complete and shorthand electronic configuration for the following atoms and ions.

    a. Si

    b. Mg^{+2}

    c. S^{-2}

    d. V

    e. Mn

    f. Ni^{+2}

    g. W

    h. Am

11. Draw the orbitals associated with the following quantum numbers.

a. n = 4, l = 0, m = 0

b. n = 2, l = 1, m = 0

c. n = 3, l = 2, m = -2

12. Arrange the following from left to right in order of increasing size:

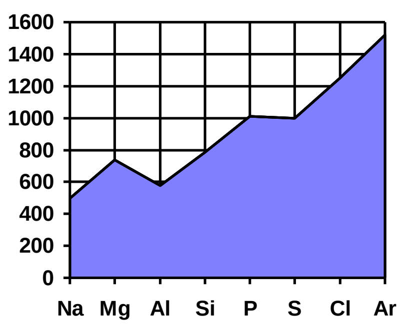
a. As, Br, Ga, Kr

b. Mg, Ba, Sr, Be

c. F^{-}, Ne, F, O^{2-}

d. K, K^{+}, Ca^{+2}, Sc^{+3}

13. Given the following ionization energy data:



a. Explain why there is an increase in ionization energy from Al to Ar.

b. Explain the slight decrease in ionization energy from P to S.

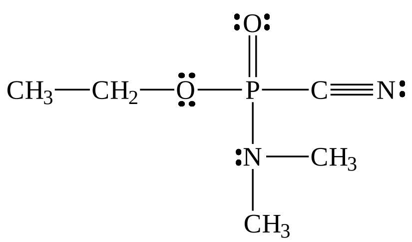
14. For each of the following pairs of ionic compounds circle the compound that has the higher lattice energy. Explain your choice in each case. (Remember that $E_{lattice} = k\,Q^{+}Q^{-}/d$ where k is a constant, Q's are the ion charges and d is the distance between ions.)

a. LiF or LiBr

b. Mg_3N_2 or NaCl

15. Draw the best resonance structure for each possible structure and assign formal charges to determine whether the connectivity in dinitrogen oxide is NNO or NON. Identify the more stable structure and explain your reasoning.

16. Tabun is a chemical warfare agent



a. How many pi bonds are there in tabun?

b. How many sigma bonds are there in tabun?

c. Give the hybridization of each carbon, nitrogen and oxygen in the molecule.

d. Which is the shortest C–N bond in the molecule?

e. What is the P–C–N bond angle?

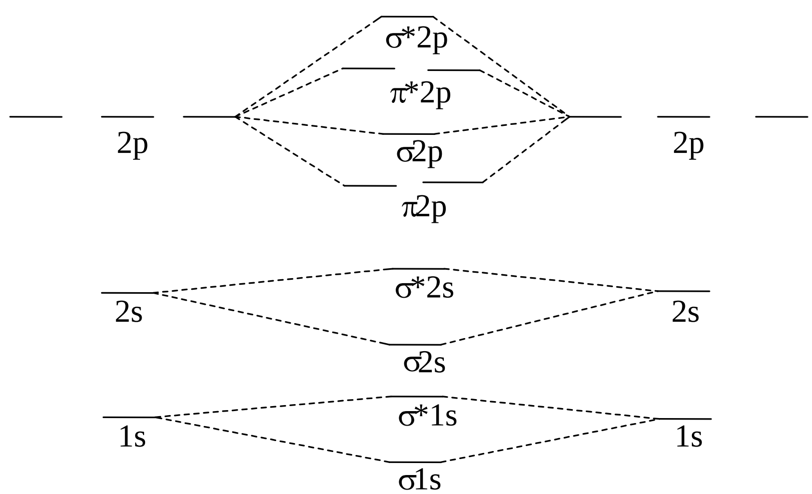
f. What is the C–N–C bond angle?

17. Complete the following table

Molecule	Lewis Diagram	Orbital geometry	molecular geometry	Hybridization
BrF_5				Br
SiO_3^{-2} (show formal charges on atoms and any resonance structures)				Si
XeO_3				Xe
PCl_3				P

18. Draw the compounds XeF_3^+ and CH_2O. Explain the bonding in terms of valence bond theory. That is show the atomic orbitals on the central atom, describe any electron promotion necessary, and show the orbitals involved in both sigma and pi bonding.

19. Nitrogen, N_2, can absorb an electron to give N_2^-. Compare these species with regard to



a. magnetic character

b. bond order

c. bond length

20. Answer the questions for the structure shown below. Note that the molecule was drawn to fit the imagination of the instructor and may not faithfully represent the geometry of the molecule. All bonds and lone pairs are shown.

a. What are the molecular and orbital geometries around Xenon?

Molecular ____________________ Orbital ____________________

b. What is the hybridization of the nitrogen atom? ________________

c. What is the formal change on the fluorine atom? _______________

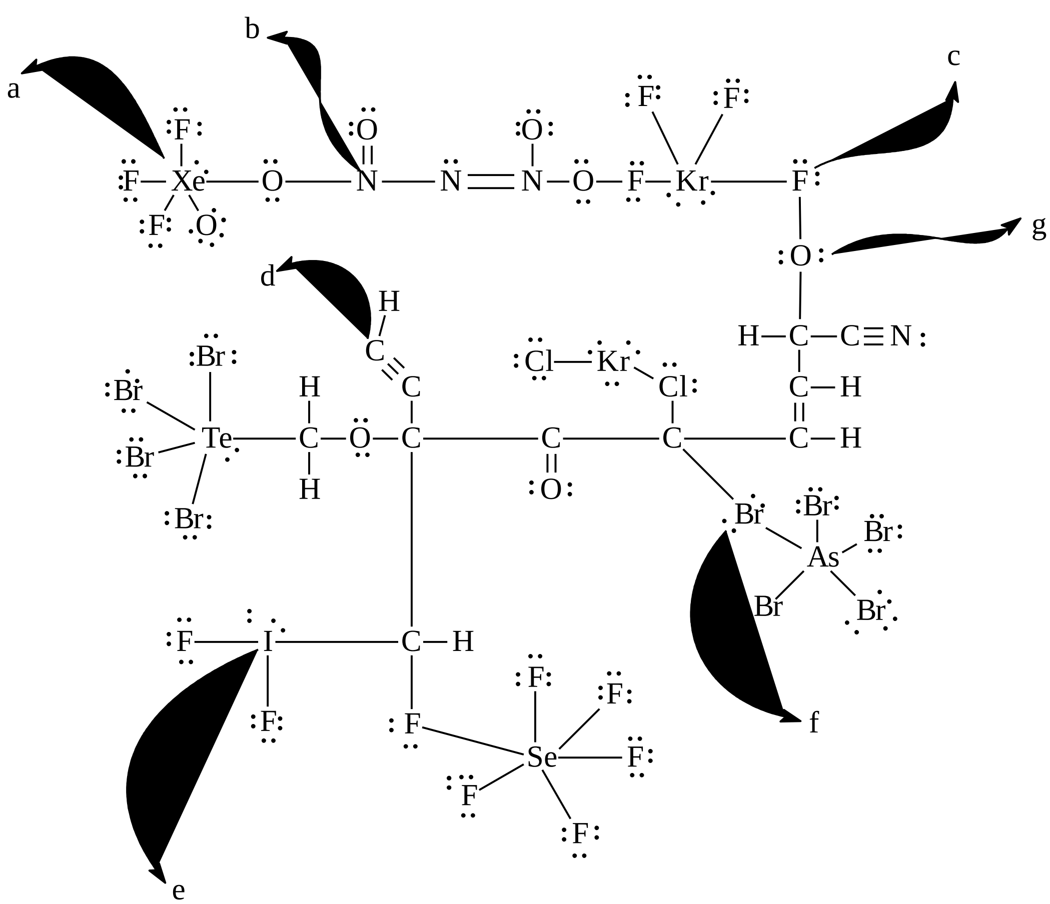
d. What is the hybridization of carbon? _____________ Charge on carbon? ________

e. What are the orbital and molecular geometries around iodine?

Molecular ____________________ Orbital ____________________

f. What is the hybridization of the bromine atom? ________________

g. What are the orbital and molecular geometries around oxygen?



21. Calculate a lattice energy for CaH_2 in kJ/mol using the following information:

E_{ea} for H = –72.8 kJ/mol

Heat of sublimation for Ca = + 178.2 kJ/mol

E_{i1} for Ca = +589.8 kJ/mol

Bond dissociation energy for H_2 = +435.9 kJ/mol

E_{i2} for Ca = +1145 kJ/mol

Net energy change for the formation of CaH_2 from its elements = –186.2 kJ/mol

(1) Molecular ______________________Orbital _____________________