AP Chemistry Problem Set Chapters 8 & 9 **Name__________________**

Multiple Choice. Please indicate your multiple choice answers below.

1. C	**2. B**	**3. D**	**4. D**	**5. A**
6. A	**7. A**	**8. D**	**9. D**	**10. E**

1. CCl_4, CO_2, PCl_3, PCl_5, SF_6 Which of the following does not describe any of the molecules above? **– 1989 (50%)**
(A) Linear (B) Octahedral **(C) Square planar** (D) Tetrahedral (E) Trigonal pyramidal

2. The melting point of MgO is higher than that of NaF. Explanations for this observation include which of the following? **- 1999 (53%)**
I. Mg^{2+} is more positively charged than Na^{+}
II. O^{2-} is more negatively charged than F^{-}
III. The O^{2-} ion is smaller than the F^{-} ion

(A) II only **(B) I and II only** (C) I and III only (D) II and III only (E) I, II, and III

3. Which ionic compound has the highest melting point?
(A) KCl (B) K_2O (C) $CaCl_2$ **(D) CaO** (E) $CaBr_2$

4. Of the following molecules, which has the largest dipole moment?
(A) CO (B) CO_2 (C) O_2 **(D) HF** (E) F_2

5. Molecules that have planar configurations include which of the following?
I. BCl_3 II. $CHCl_3$ III. NCl_3

(A) I only (B) III only (C) I and II only (D) II and III only (E) I, II, and III

6. The electron-dot structure (Lewis structure) for which of the following molecules would have two unshared pairs of electrons on the central atom?
(A) H_2S (B) NH_3 (C) CH_4 (D) HCN (E) CO_2

7. Which of the following molecules has a dipole moment of zero?
(A) C_6H_6 (benzene) (B) NO (C) SO_2 (D) NH_3 (E) H_2S

8. Types of hybridization exhibited by the C atoms in propene, CH_3CHCH_2, include which of the following?
I. sp
II. sp^2
III. sp^3
(A) I only (B) III only (C) I and II only **(D) II and III only** (E) I, II, and III

9. The $SbCl_5$ molecule has trigonal bipyramid structure. Therefore, the hybridization of Sb orbitals should be:
(A) sp^2 (B) sp^3 (C) dsp^2 **(D) dsp^3** (E) d^2sp^3

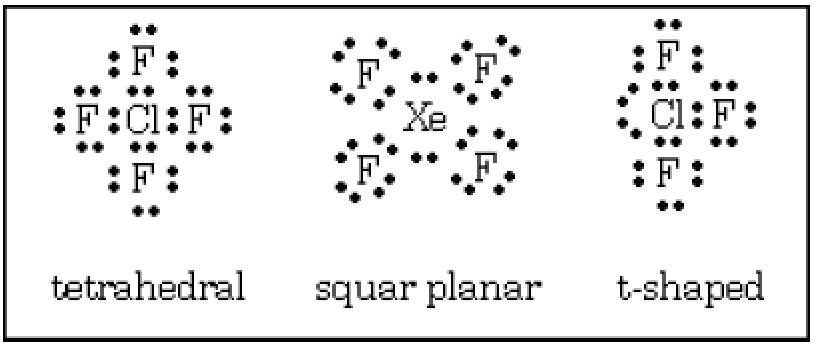
10. Which of the following compounds is ionic and contains both sigma and pi covalent bonds?
(A) $Fe(OH)_3$ (B) HClO (C) H_2S (D) NO_2 **(E) NaCN**

Essays:

#1. (1989 - #5) Average Score: 2.7 out of 8

CF_4 XeF_4 ClF_3

(a) Draw a Lewis electron-dot structure for each of the molecules above and identify the shape of each.



(b) Use the valence shell electron-pair repulsion (VSEPR) model to explain the geometry of each of these molecules.

CF_4 - 4 bonding pairs around the C at corners of regular tetrahedron to minimize repulsion (maximize bond angles).

XeF_4 - 4 bonding pairs and 2 lone pairs give octahedral shape with lone pairs on opposite sides of Xe atoms.

ClF_3 - 3 bonding pairs and 2 lone pairs give trigonal bipyramid with lone pairs in equatorial positions 120° apart.

#2. (1990 - #5)

Use simple structure and bonding models to account for each of the following.

(a) The bond length between the two carbon atoms is shorter in C_2H_4 than in C_2H_6.

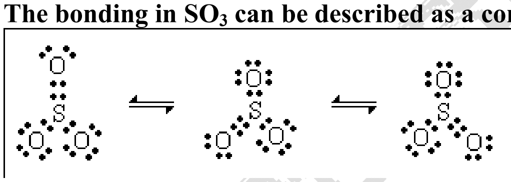
C_2H_4 has a multiple bond; C_2H_6 has a single bond. Multiple bonds are stronger and therefore shorter than single bonds.

(b) The H - N - H bond angle is 107.5° in NH_3.

NH_3 has 3 bonding pairs and 1 lone pair of electrons. Bond pairs are forced together because the repulsion between the lone pair and the bond pairs is greater than that between bond pairs.

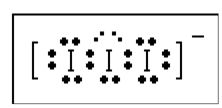
(c) The bond lengths in SO_3 are all identical and are shorter than a sulfur-oxygen single bond.

The bonding in SO_3 can be described as a combination of 3 resonance forms of 1 double and single bonds.



The actual structure is intermediate between the 3 resonance forms, having 3 bonds which are equal and stronger (therefore shorter) than a S-O single bond.

(d) The I_3^- ion is linear.



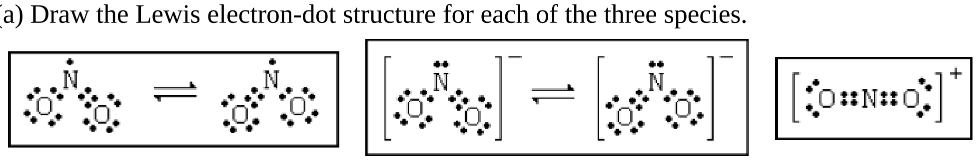
The central I atom has 3 lone pairs and 2 bond pairs around it. To minimize repulsion, the 3 lone pairs are arranged in a trigonal plane at right angles to the I-I-I axis.

#3 (1992 - #9) Average Score: 2.5 out of 8

NO_2 NO_2^- NO_2^+

Nitrogen is the central atom in each of the species given above.

(a) Draw the Lewis electron-dot structure for each of the three species.



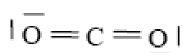
For NO_2, a correct structure with one electron on the single bonded oxygen is OK (Actually I would prefer it because the charge supports it). Note added to standards: Although not required by the wording of the question, both resonance forms are shown.

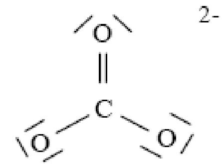
(b) List the species in order of increasing bond angle. Justify your answer.
$NO_2^- < NO_2 < NO_2^+$
(c) Select one of the species and give the hybridization of the nitrogen atom in it.
NO_2^+ is sp, NO_2 is sp^2, NO_2^- is sp^2
(d) Identify the only one of the species that dimerizes and explain what causes it to do so.
NO_2 will dimerize because it contains an odd electron that will pair readily with another, giving N_2O_4.

#4. (1999 - #8)
Answer the following questions using principles of chemical bonding and molecular structure.

Consider the carbon dioxide molecule, CO_2 , and the carbonate ion, CO_3^{2-}.

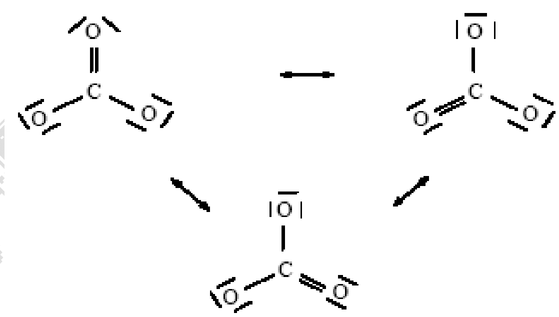
a. Draw the complete Lewis electron-dot structure for each species.





b. Account for the fact that the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2.

In CO_2, the C−O interactions are double bonds. In CO_3^{2-} the C−O interactions are resonance forms (or figures to the right.) The carbon-oxygen bond length is greater in the resonance forms than in the double bonds.



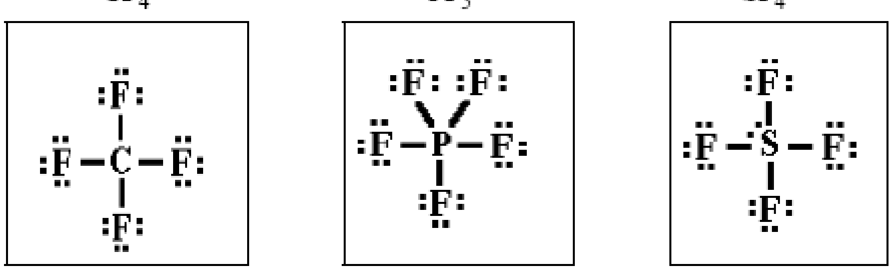
Consider the molecules CF_4 and SF_4.

a. Draw the complete Lewis electron-dot structure for each molecule.

b. In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.
CF_4 has a tetrahedral geometry, so the bond dipoles cancel, leading to a nonpolar molecule. With five pairs of electrons around the central S atom, SF_4 exhibits a trigonal bipyramidal electronic geometry, with the lone pair of electrons. In this configuration, the bond dipoles do not cancel, and the molecule is polar.

#5. (2005 - #6)
Answer the following questions that relate to chemical bonding.
(a) In the boxes provided, draw the complete Lewis structure (electron-dot diagram) for each of the three molecules represented below.

CF_4 PF_5 SF_4



(b) On the basis of the Lewis structures drawn above, answer the following questions about the particular molecule indicated.

(i) What is the F –C –F bond angle in CF_4?

109.5°

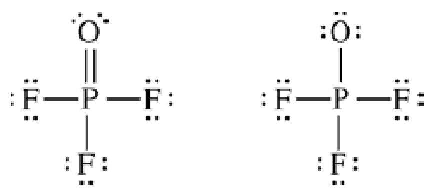
(ii) What is the hybridization of the valence orbitals of P in PF_5?

dsp^3

(iii) What is the geometric shape formed by the atoms in SF_4?

seesaw

(c) Two Lewis structures can be drawn for the OPF_3 molecule, as shown below.



Structure 1 Structure 2

(i) How many sigma bonds and how many pi bonds are in structure 1?

4 sigma bonds and 1 pi bond

(ii) Which one of the two structures best represents a molecule of OPF_3? Justify your answer in terms of formal charge.

Structure 1 is the better structure because all of its atoms have a formal charge of zero.

P: 5 – 5 – 0 = 0

F: 7 – 1 – 6 = 0

O: 6 – 2 – 4 = 0