

Problem Set #12
CHEM101A: General College Chemistry

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11 Topic F Problem 11

There are two ions that have the empirical formula CNO^- . The cyanate ion has the three atoms in the order N-C-O, while the fulminate ion has the three atoms in the order C-N-O.

- a) Draw all of the resonance structures that satisfy the octet rule for each ion. Include all non-zero formal charges in your structures.
- b) Based on formal charges, which of these resonance structures would you expect to make a significant contribution to the actual structures of the cyanate and fulminate ions?
- c) Based on your resonance structures for the cyanate ion, which atom (or atoms) carries the negative charge?
- d) Repeat part c for the fulminate ion.

11.1 Solution

12 Topic F Problem 12

Draw all of the reasonable resonance structures that satisfy the octet rule for each of the following substances, and tell which structures will be major contributors to the actual structure of the molecule or ion.

- a) CO_3^{2-}
- b) HCO_3^- (the H is attached to one of the O atoms in CO_3^{2-})
- c) H_2CO_3 (each H is attached to one of the O atoms in CO_3^{2-})

12.1 Solution

13 Topic F Problem 13

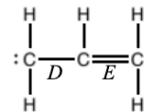
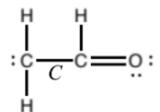
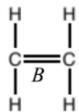
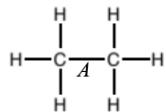
Each of the three substances in the previous problem contains three carbon-oxygen bonds. For each substance, which carbon-oxygen bonds are the same length?

13.1 Solution

- a/ All three are the same length.
- b/ The ones not with oxygens not bonded to hydrogens.
- c/ The ones with oxygens bonded to hydrogens.

14 Topic F Problem 14

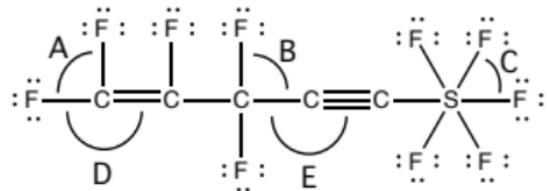
Rank the bonds labeled A through E in order of carbon-carbon bond distance, starting with the shortest bond distance. Be sure to consider resonance!



14.1 Solution

15 Topic F Problem 15

What are the approximate values (in degrees) for the bond angles labeled A through E in the molecule below?



15.1 Solution

A: 120°

B: 109.5°

C: 90°

D: 120°

E: 180°

16 Topic F Problem 16

For each of the following pairs of molecules, one molecule is polar while the other is not. Tell which molecule is polar, and justify your answer using Lewis structures and VSEPR.

- | | |
|--|--|
| a) CO ₂ and SO ₂ | c) SiF ₄ and SeF ₄ |
| b) NCl ₃ and BCl ₃ | d) IF ₅ and PF ₅ |

16.1 Solution

17 Topic F Problem 17

What is the hybridization on each of the following atoms?

- a) The nitrogen atom in NH₃
- b) The phosphorus atom in PF₅
- c) The carbon atom in CO₂
- d) The carbon atom in CH₂O
- e) The iodine atom in IF₅
- f) The nitrogen atom in NO₂⁻

17.1 Solution

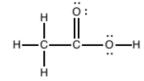
18 Topic F Problem 18

List all of the valence orbitals in each of the atoms listed in the previous problem, and tell how many of each there are. Do not list orbitals on the outer atoms.

18.1 Solution

19 Topic F Problem 19

According to the valence-bond model, what atomic orbitals overlap to form each of the following chemical bonds?



- a) The H–Br bond in HBr
- b) The I–I bond in I₂
- c) A C–F bond in CF₄
- d) The C–H bond in HCN
- e) A C–Cl bond in COCl₂
- f) The C–C bond in acetic acid (the molecule on the right)
- g) The C–O single bond in acetic acid

19.1 Solution

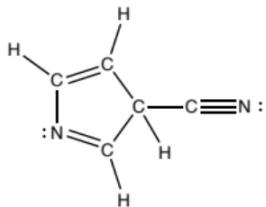
20 Topic F Problem 20

According to the valence-bond model, what atomic orbitals hold the nonbonding electrons in a molecule of water?

20.1 Solution

21 Topic F Problem 21

Questions a through d (on the next page) refer to the molecule below.



- a) How many sigma bonds and how many pi bonds are there in this molecule?
- b) What atomic orbitals form the carbon-nitrogen double bond? Tell whether each orbital is involved in a sigma bond or a pi bond.
- c) What atomic orbitals form the carbon-nitrogen triple bond? Tell whether each orbital is involved in a sigma bond or a pi bond.
- d) What atomic orbitals contain the nonbonding electrons?

21.1 Solution

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