Chapter 10 Answers

Practice Examples

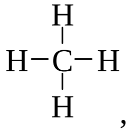
1a. $\cdot\mathrm{Mg}\cdot$, $\cdot\overset{\cdot}{\underset{\cdot}{\mathrm{Ge}}}\cdot$, $\mathrm{K}\cdot$, $:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Ne}}}:$

1b. $\cdot\overset{\cdot}{\underset{\cdot}{\mathrm{Sn}}}\cdot$, $[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Br}}}:]^-$, $[\cdot\mathrm{Tl}\cdot]^+$, $[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{S}}}:]^{2-}$

2a. (a) $[\mathrm{Na}]^+[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{S}}}:]^{2-}[\mathrm{Na}]^+$; (b) $[\mathrm{Mg}]^{2+}[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{N}}}:]^{3-}[\mathrm{Mg}]^{2+}[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{N}}}:]^{3-}[\mathrm{Mg}]^{2+}$.

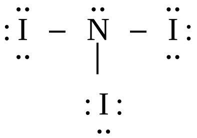
2b. (a) $[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{I}}}:]^-[\mathrm{Ca}]^{2+}[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{I}}}:]^-$; (b) $[\mathrm{Ba}]^{2+}[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{S}}}:]^{2-}$; (c) $[\mathrm{Li}]^+[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{O}}}:]^{2-}[\mathrm{Li}]^+$.

3a. $:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Br}}} - \overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Br}}}:$,



, $\mathrm{H} - \overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{O}}} - \overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Cl}}}:$

3b.



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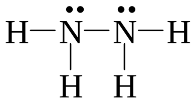

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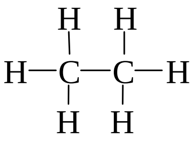


4a. N—H and P—Cl bonds are the most polar of the four bonds cited.

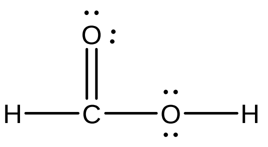
4b. The P — O bond is the most polar of the four bonds cited.

5a. The electrostatic potential map that corresponds to IF is the one with the most red in it.

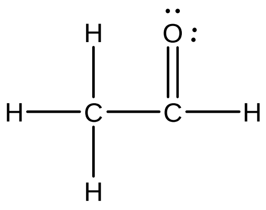
5b. The electrostatic potential map that corresponds to CH_3OH is the one with the most red in it.

6a. (a) $:\overset{\cdot\cdot}{\mathrm{S}} = \mathrm{C} = \overset{\cdot\cdot}{\mathrm{S}}:$; (b) $\mathrm{H}-\mathrm{C}\equiv\mathrm{N}:$; (c) $:\overset{\cdot\cdot}{\mathrm{O}} = \mathrm{C}(-\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Cl}}}:)_2$.

6b. (a)



; (b)



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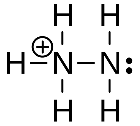
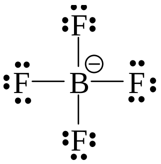
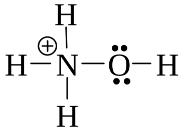
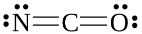
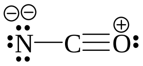
7a. (a) $:\mathrm{N}\equiv\overset{\oplus}{\mathrm{O}}:$; (b)



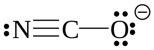
(c) $:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{O}}}:^{2-}$

7b. (a)  ; (b)  ; (c) 

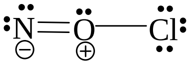
Structure 1

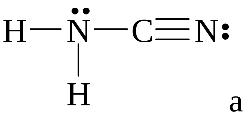
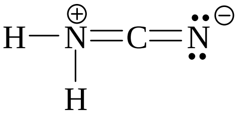


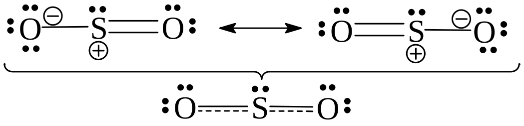
Structure 2

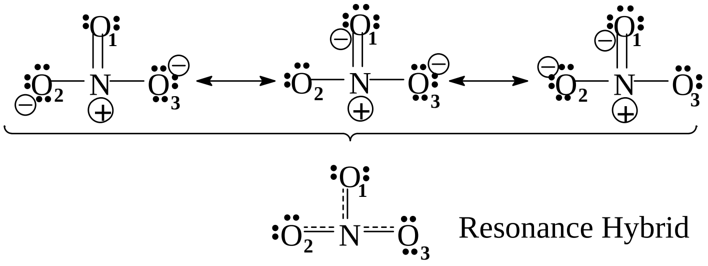


Structure 3

8a.  is much poorer than the one derived in Example 10-8 because it has a positive formal charge on oxygen, which is the most electronegative atom in the molecule.

8b.  and  . The first structure is the better of the two structures because it has no formal charges.

9a. 

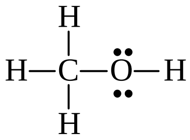
9b. 

10a. Trigonal pyramidal

10b. Tetrahedral

11a. Linear

11b. Linear

12a.  $\mathrm{H-\overset{H}{\underset{H}{C}}-\ddot{\underset{\cdot\cdot}{O}}-H}$. The H—C—H bond angles are ~109.5º, as are the H—C—O bond angles. Around the O there are two bonding pairs of electrons and two lone pairs, resulting in a tetrahedral electron-group geometry and a bent molecular shape around the O atom, with a $\mathrm{C-O-H}$ bond angle of slightly less than 109.5°.

12b. . The $\mathrm{H-N-H}$ bond angle and the $\mathrm{H-N-C}$ bond angles are almost the tetrahedral angle of 109.5°, made a bit smaller by the lone pair. The $\mathrm{H-C-N}$ angles, the $\mathrm{H-C-H}$ angle and the H—C—C angles all are very close to 109.5°. The $\mathrm{C-O-H}$ bond angle is made somewhat smaller than 109.5° by the presence of two lone pairs on O. Three electron groups surround the right-hand C, making its electron-group and molecular geometries trigonal planar. The $\mathrm{O-C-O}$ bond angle and the $\mathrm{O-C-C}$ bond angles all are very close to 120°.

13a. In H_2O_2, the molecular geometry around each O atom is bent; the bond moments do not cancel. H_2O_2 is polar.

13b. PCl_5 as the only nonpolar species; it is a highly symmetrical molecule in which individual bond dipoles cancel out.

14a. From Table 10.2, the length of a $\mathrm{C-H}$ bond is 110 pm. The length of a $\mathrm{C-Br}$ bond is not given in the table. A reasonable value is the average of the $\mathrm{C-C}$ and $\mathrm{Br-Br}$ bond lengths = 195pm.

14b. $|\overline{\underline{\mathrm{S}}}-\mathrm{C}\equiv\mathrm{N}|$, linear.

15a. -486 kJ/mol

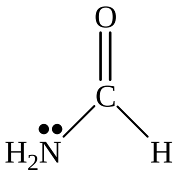
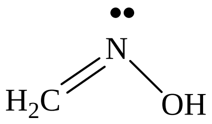
15b. -4×10^1 kJ/mol NH_3

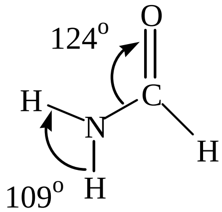
16a. Exothermic

16b. Endothermic

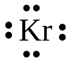
Integrative Example

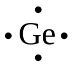
A $\mathrm{P-Cl}=-165.5\ \mathrm{kJ/mol}$. Since the geometries of the two molecules differ, the orbital overlap between P and the surrounding Cl atoms will be different and therefore the P–Cl bonds in these two compounds will also be slightly different.

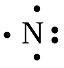
B. (a)Formamide: , bond energy = 2233 kJ/mol ; Formaldoxime: , bond energy = 2129 kJ / mol . Since BE of formamide is greater than that of formaldoxime, it is more stable, and its conversion endothermic.

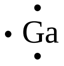
(b) 

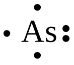
Exercises

1a. 

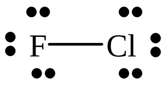
1b. 

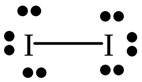
1c. 

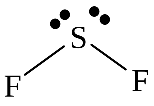
1d. 

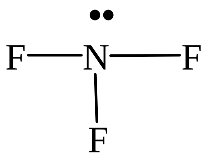
1e. 

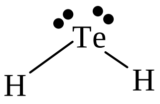
1f. 

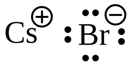
3a. 

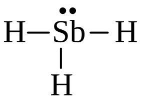
3b. 

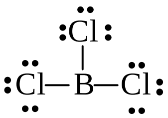
3c. 

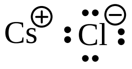
3d. 

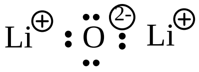
3e. 

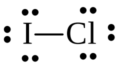
5a. 

5b. 

5c. 

5d. 

5e. 

5f. 

7. NO_2, BF_3 , SF_6.

9a. Has two bonds (4 electrons) to the second hydrogen, and only six electrons around the nitrogen.

9b. It is improperly written as a covalent Lewis structure. CaO is actually an ionic compound.

11. The answer is (c). The flaws with the other answers are as follows: (a) C does not have an octet of electrons; (b) Neither C has an octet of electrons and the total number of valence electrons is incorrect; (c) The total number of valence electrons is incorrect.

13a. $[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Cl}}}:]^-[\mathrm{Ca}]^{2+}[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Cl}}}:]^-$

13b. $[\mathrm{Ba}]^{2+}[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{S}}}:]^{2-}$

13c. $[\mathrm{Li}]^+[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{O}}}:]^{2-}[\mathrm{Li}]^+$

13d. $[\mathrm{Na}]^+[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{F}}}:]^-$

15a. $[\mathrm{Li}]^+[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{S}}}:]^{2-}[\mathrm{Li}]^+$

15b. $[\mathrm{Na}]^+[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{F}}}:]^-$

15c. $[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{I}}}:]^-[\mathrm{Ca}]^{2+}[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{I}}}:]^-$

15d.
$$\begin{array}{c} [:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Cl}}}:]^- \\ [:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Cl}}}:]^-[\mathrm{Sc}]^{3+}[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Cl}}}:]^- \end{array}$$

17a.

H—	—C≡	≡C
0	0	–1

17b.

=O	—O(×2)	C
–0	–1	0

17c.

—H(×7)	side C(×2)	central C
0	0	+1

19. For instance, there are cases where atoms of the same type with the same oxidation state have different formal charges, such as oxygen in ozone, O_3. Another is that formal charges are used to decide between alternative Lewis structures, while oxidation state is used in balancing equations and naming compounds. Also, the oxidation state in a compound is invariant, while the formal charge can change. The most significant difference, though, is that whereas the oxidation state of an element in its compounds is usually not zero, its formal charge usually is.

21a. +1

21b. -1

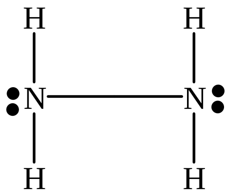
21c. 0

21d. -2

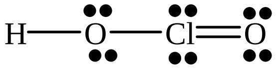
21e. 0

23. Based on formal charge rules alone, we must conclude that structures (A) and (B) are equally plausible.

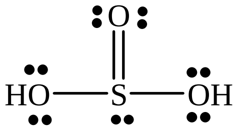
25a.



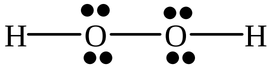
25b.



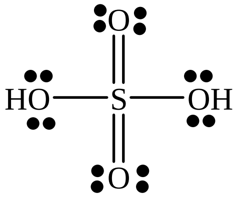
25c.



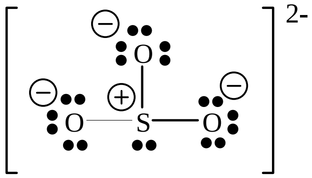
25d.



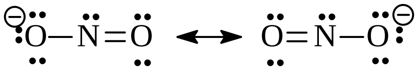
25e.



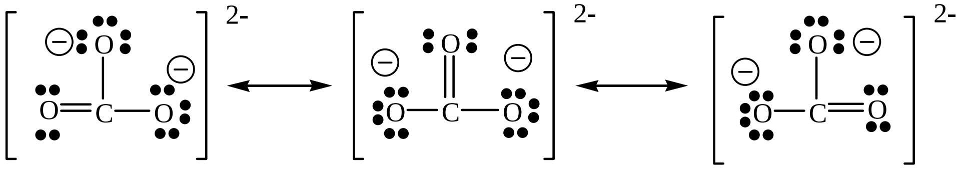
27a.



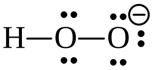
27b.

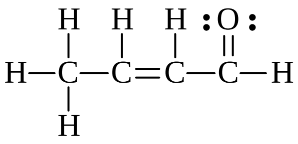


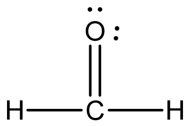
27c.

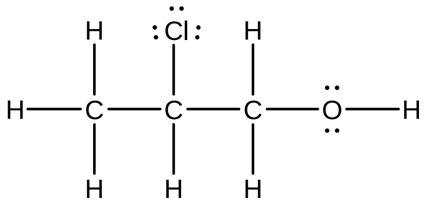


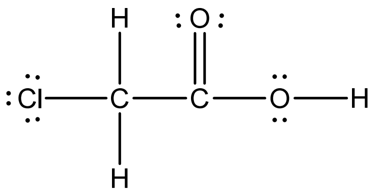
27d.

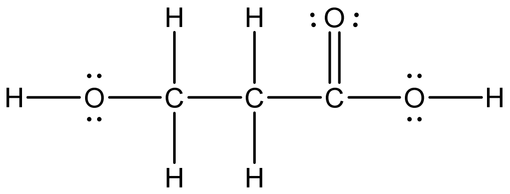


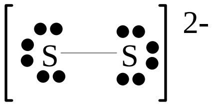
29. 

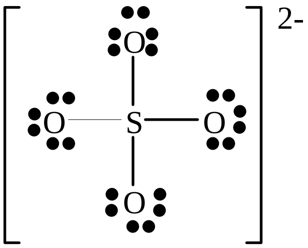
31a. 

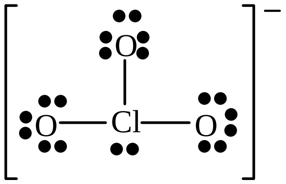
31b. 

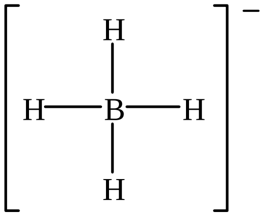
33a. 

33b. 

35a. Group 16,  .

35b. Group 16 except oxygen,  .

35c. Group 17 except fluorine,  .

35d. Group 13,  .

37. C — H < Br — H < F — H < Na — Cl < K — F

39a. 4%

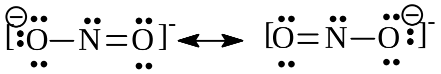
39b. 5%

39c. 60%

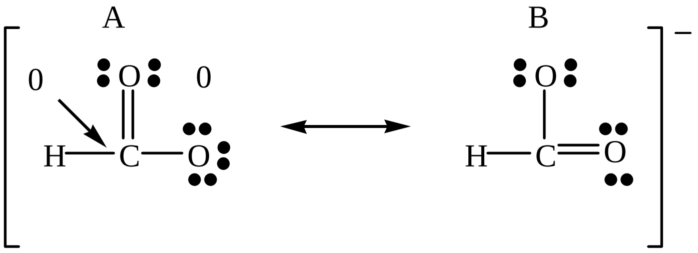
39d. 33%

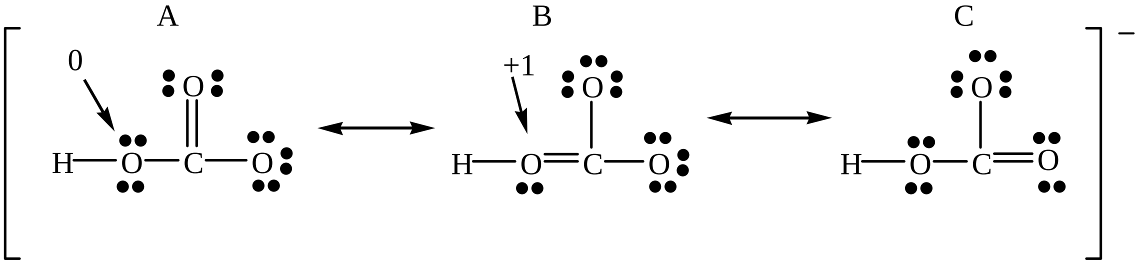
43. $F_2C=O$ is represented on the left, while $H_2C=O$ is represented on the right.

45. The molecular formulas for the compounds are SF_4 and SiF_4. The electrostatic potential map on the right is for SiF_4.

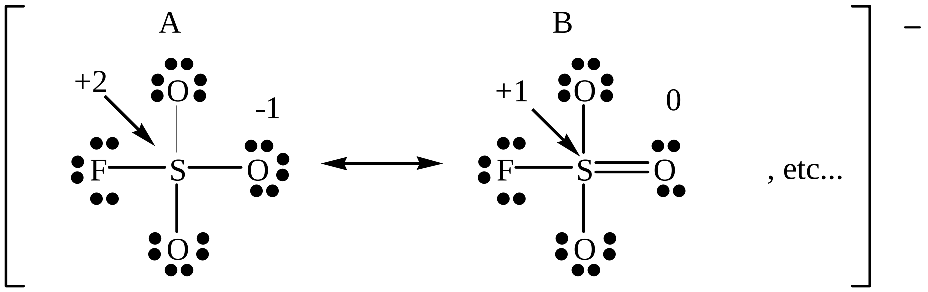
47. 

49. The molecule seems best represented as a resonance hybrid of (a) and (b).

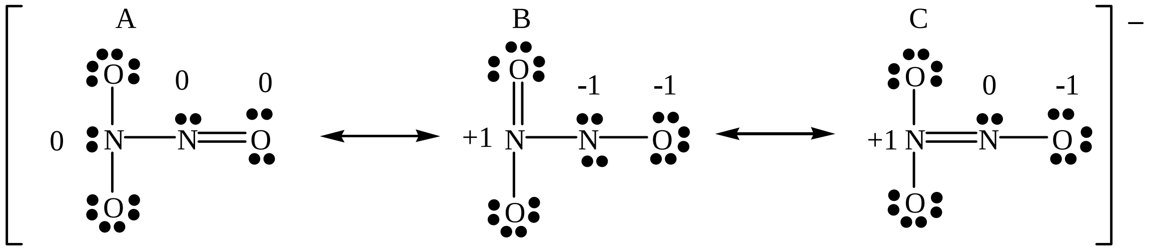
51a. 

51b. 

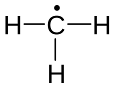
51c.



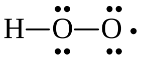
51d.



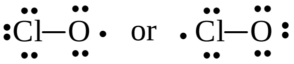
53a.



53b.



53c.



55a. Diamagnetic

55b. Paramagnetic

55c. Paramagnetic

55d. Diamagnetic

55e. Diamagnetic

55f. Paramagnetic

57. SF_4 and ICl_3 require expanded octets. The others do not.

59a. Linear

59b. Linear

59c. Tetrahedral

59d. Trigonal Planar

59e. Bent

61a. Bent

61b. Planar

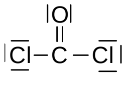
61c. Linear

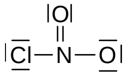
61d. Octahedral

61e. Tetrahedral

63. CO_3^{2-}

65a. $\overline{\underline{O}} = C = \overline{\underline{O}}$, linear.

65b. 
$|\overline{\underline{Cl}}-\overset{\overset{|O|}{\|}}{C}-\overline{\underline{Cl}}|$, trigonal planar.

65c. 
$|\overline{\underline{Cl}}-\overset{\overset{|O|}{\|}}{N}-\overline{\underline{O}}|$

67a. Tetrahedral

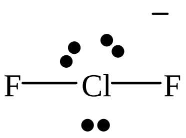
67b. Tetrahedral

67c. Octahedral

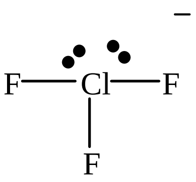
67d. Linear

69. Tetrahedral

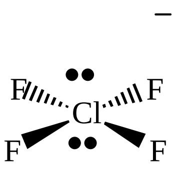
71. Looking at the structures, the molecular angle/shape depends on the number of valence electron pairs on the central atom. The more pairs there are, the more acute the angle becomes.

73a. 

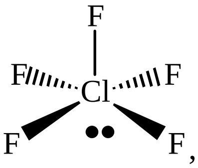
, trigonal bipyramidal, linear.

73b. 

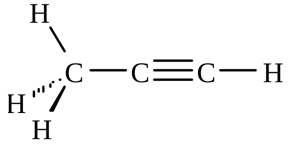
, trigonal bipyramidal, t-shaped.

73c. 

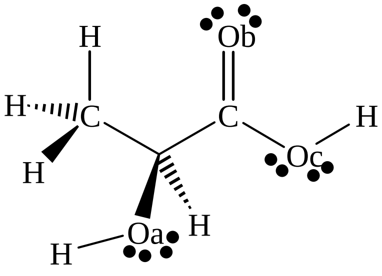
, octahedral, square planar.

73d. 

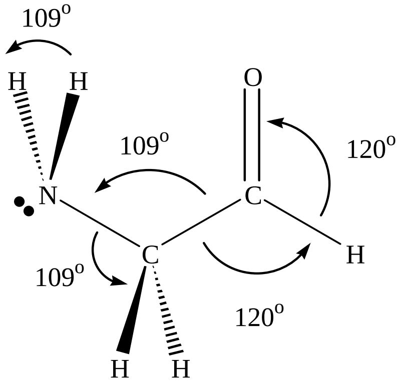
, octahedral, square pyramidal.

75. 

A maximum of 5 atoms can be in the same plane

77. 

all angles ~109.5 except O_c-C-C, O_b=C-C, and O_b=C-O_c which are 120°

79. 

81a. Bent, polar.

81b. Trigonal pyramidal, polar.

81c. Bent, polar.

81d. Planar, nonpolar.

81e. Octahedral, nonpolar.

81f. Tetrahedral, polar.

83. It cannot be linear.

85. Br_2 possess the longest bond. Single bonds are generally longer than multiple bonds.

87a. 233 pm

87b. 172 pm

87c. 149 pm

87d. 191 pm

89. 144 pm

91. Endothermic

93. -113 kJ/mol

95a. $\Delta H_f^o = 39$ kJ / mol

95b. $\Delta H_f^o = 99$ kJ

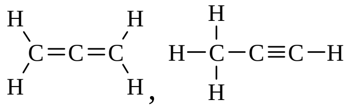
97. -166 kJ/mol

99. 448 kJ/mol

Integrative and Advanced Exercises

101. -744 kJ/mol

104. 42.0 g/mol , C_3H_6.

106.  . Neither is completely linear.

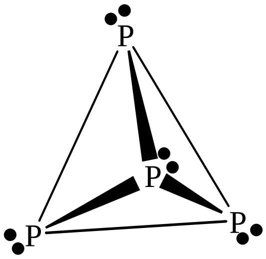
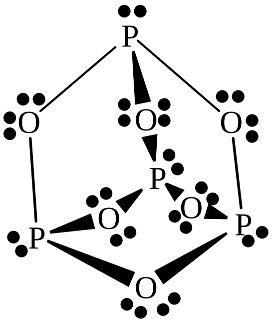
109. $\mathrm{H{-}\overline{N}{=}N{=}\underline{\overline{N}}}$, $\mathrm{H{-}\underline{\overline{N}}{-}N{\equiv}N|}$.

110. Bent

113. +103 kJ

116. 307 kJ

120. F = 0.0019$\underline{9}$, Cl = 0.0018$\underline{7}$, Br = 0.0019$\underline{1}$, I = 0.0019$\underline{2.}$ *EA* ~ -260 kJ/mol. *EA* for At : ~ -260 kJ/mol.

127. , . The P–O–P bond is not linear.

128a. 91 kJ/mol

128b. ΔEN = 0.97

128c. 23%

129a. 1.49 D

129b. Approximately 92°.

129c. 97.6°

Self-Assessment Exercises

134. The answer is (b).

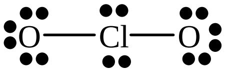
135. The answer is (c).

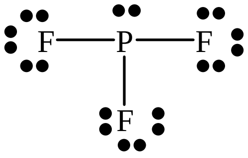
136. The answer is (a).

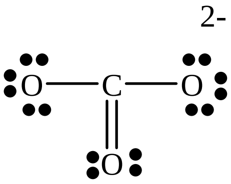
137. The answer is (a).

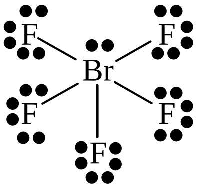
138. The answer is (b).

139. The answer is (c).

140a. 

140b. 

140c. 

140d. 

141a. Bent

141b. Trigonal pyramidal

141c. Tetrahedral

142. Bi

143.

Bond	Bond Energy (kJ/mol)	Bond Length (pm)
C–H	414	110
C=O	736	120
C–C	347	154
C–Cl	339	178

144. VSEPR theory is valence shell electron pair repulsion theory. It is based on the premise that electron pairs assume orientations about an atom to minimize electron pair repulsions.

145. Since there are 4 electron pairs around the central atom, the way to maximize the distance between them is to set up a tetrahedral electron group geometry. However, since there are only three atoms bonding to the central atom, the molecular geometry is trigonal pyramidal.

146. A pyramidal geometry is observed when an atom has one lone pair and is bonded to three other atoms (AX_3E). A bent geometry is observed when an atom has two lone pairs and is bonded to two other atoms (AX_2E_2). For both, the bond angles will be approximately (usually smaller than) 109°.

147.