3.091 Fall Term 2004

Homework #4

Solutions

5-5. We imply that sodium is a better electron donor than lithium. Evidence for this can be found in the lower value of AVEE which for these two elements is equivalent to the value of the first ionization energy. For sodium the value is 5.139 eV; for lithium 5.392 eV.

5-47. The very high third ionization energy for magnesium (7733 kJ).

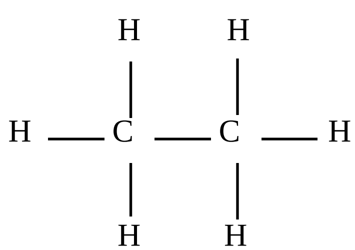
5-49. The most important factor is the electron configuration and the number of electrons that must be gained or lost to achieve a filled outer shell or octet electron configuration.

5-51. The product of the reaction of strontium metal with phosphorus should have the formula Sr_3P_2.

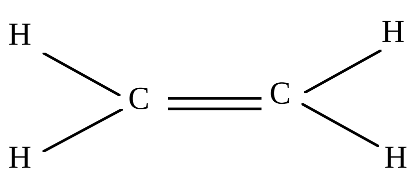
5-55. (a) ZnF_2 (b) AlF_3 (c) SnF_2 or SnF_4 (d) MgF_2 (e) (BiF_3 or BiF_5

4-34.

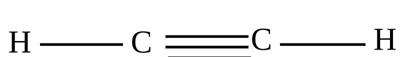
(a) C_2H_6



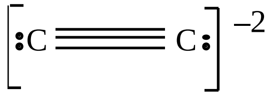
(b) C_2H_4



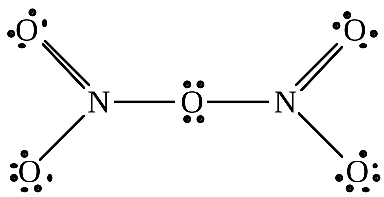
(c) C_2H_2



(d) C_2^{2-}

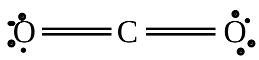


4-37. In the molecule N_2O_5, there are 40 valence electrons available. A structure that contains $O_2N\text{-}NO_3$ requires 42 valence electrons. The correct Lewis structure is:



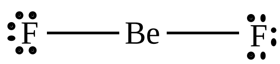
4-42. Exceptions to the Lewis octet rule are encountered when the central atom has fewer than or more than eight valence electrons.

(a) CO_2



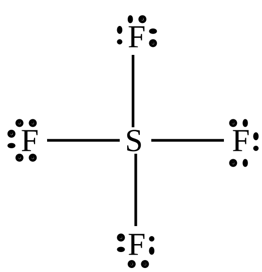
CO_2 is not an exception to the octet rule.

(b) BeF_2



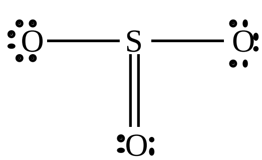
Be is surrounded by four valence electrons. This is an exception to the octet rule.

(c) SF_4

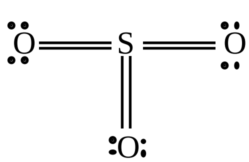


Sulfur is surrounded by ten valence electrons. This is an exception to the octet rule.

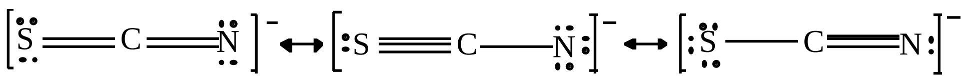
(d) SO_3



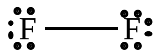
SO_3 is not an exception to the octet rule. An alternate structure would be



4-51. The resonance structures of SCN^- are:



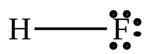
4-59. (a)



$$\delta_F = G_F - N_F - B_F\left(\frac{EN_F}{EN_F + EN_F}\right)$$

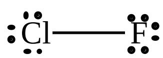
$$\delta_F = 7 - 6 - 2\left(\frac{4.19}{4.19+4.19}\right) = 7 - 6 - 1 = 0$$

(b)



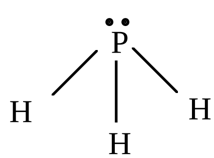
$$\delta_F = 7 - 6 - 2\left(\frac{4.19}{4.19+2.30}\right) = 7 - 6 - 1.29 = -0.29$$

(c)



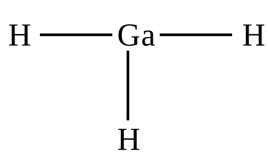
$$\delta_F = 7 - 6 - 2\left(\frac{4.19}{4.19+2.87}\right) = 7 - 6 - 1.19 = -0.19$$

4-86. (a) PH_3



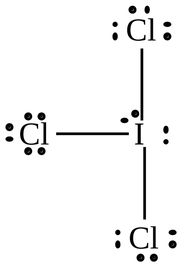
Number of bonding domains = 3; Number of nonbonding domains = 1
Geometry = trigonal pyramidal

(b) GaH_3



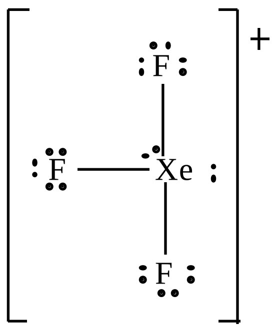
Number of bonding domains = 3; Number of nonbonding domains = 0
Geometry = trigonal planar

(c) ICl_3



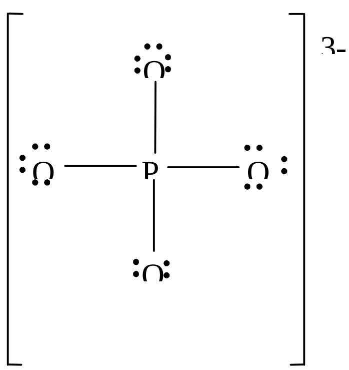
Number of bonding domains = 3; Number of nonbonding domains = 2
Geometry = T-shaped

(d) XeF_3^+



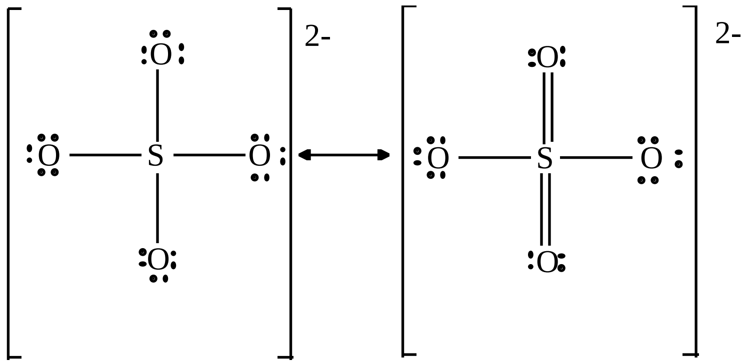
Number of bonding domains = 3; Number of nonbonding domains = 2
Geometry = T-shaped

4-87. (a) PO_4^{3-}



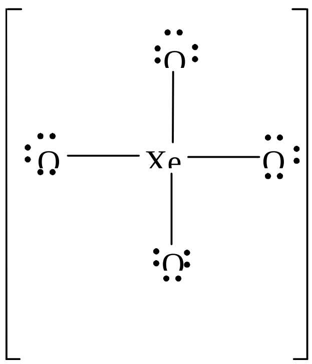
Number of bonding domains = 4; Number of nonbonding domains = 0
Geometry = tetrahedral

(b) SO_4^{2-}



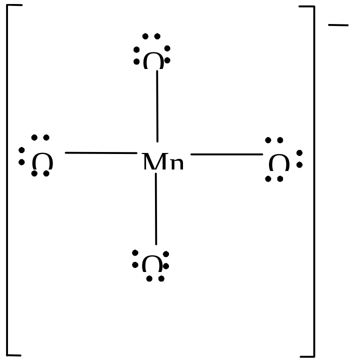
Number of bonding domains = 4; Number of nonbonding domains = 0
Geometry = tetrahedral

(c) XeO_4



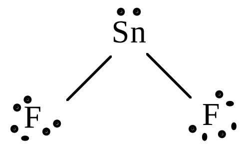
Number of bonding domains = 4; Number of nonbonding domains = 0
Geometry = tetrahedral

(d) MnO_4^-



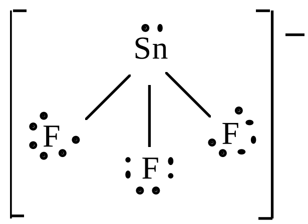
Number of bonding domains = 4; Number of nonbonding domains = 0
Geometry = tetrahedral

4-88. (a) SnF_2



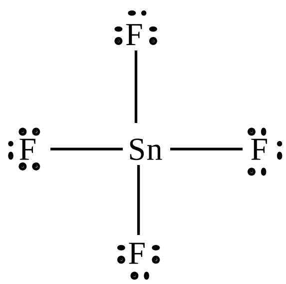
Number of bonding domains = 2; Number of nonbonding domains = 1
Geometry = bent

(b) SnF_3^-



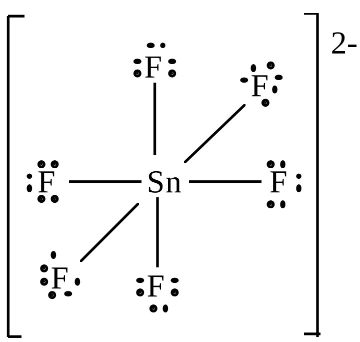
Number of bonding domains = 3; Number of nonbonding domains = 1
Geometry = trigonal pyramidal

(c) SnF_4



Number of bonding domains = 4; Number of nonbonding domains = 0
Geometry = tetrahedral

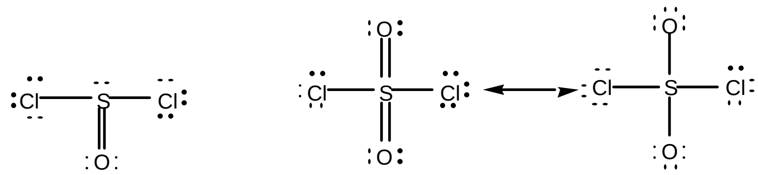
(d) SnF_6^{2-}



Number of bonding domains = 6; Number of nonbonding domains = 0
Geometry = octahedral

4-111. All are polar.

4-113. The Lewis structures of thionyl chloride ($SOCl_2$) and sulfuryl chloride (SO_2Cl_2) are:



thionyl chloride sulfuryl chloride

Thionyl chloride has a dipole moment along the S-O bond. Therefore, it is a polar molecule. There are two possible structures that could be drawn for sulfuryl chloride, and both structures have a tetrahedral arrangement. Since there are two types of polar bonds in the molecule, S-Cl and S-O, the individual bond dipoles do not cancel. Sulfuryl chloride is a polar molecule.

4-A5.

(a)	CH_4	sp^3
(b)	H_2CO	sp^2
(c)	HCO_2^-	sp^2

4-A6.

(a)	SF_4	sp^3d
(b)	BrO_3	sp^3
(c)	XeF_{3+}	sp^3d
(d)	Cl_2CO	sp^2

Additional questions:

1. $E_{lattice} = \dfrac{Mq_1q_2}{4\pi\varepsilon_o r_o}\left(1-\dfrac{1}{n}\right)$ and $r_o = r_{Cs^+} + r_{Cl^-}$

Solve first for r_o

$$r_o = \frac{Mq_1q_2N_{Av}}{4\pi\varepsilon_o E_{lattice}}\left(1-\frac{1}{n}\right) = \frac{1.763\left(1.6\times10^{-19}\right)^2 6.02\times10^{23}}{4\pi 8.85\times10^{-12} 6.33\times10^5}\left(1-\frac{1}{10.7}\right)$$

$= 3.50 \times 10^{-10}$ m $= 3.50$ Å $= r_{Cs^+} + r_{Cl^-}$

$\therefore\ r_{Cs^+} = 3.50 - 1.81 = 1.69$ Å

2. (a) Chlorine will be liberated if the C-Cl bond breaks, $\therefore$ compute its strength and show that ultraviolet photons have enough energy to break the bond.

$$E_{C-Cl} = \sqrt{E_{C-C} \times E_{Cl-Cl}} + 96.3(\chi_C - \chi_{Cl})^2$$

$$= \sqrt{347 \times 242} + 96.3(2.55 - 3.16)^2$$

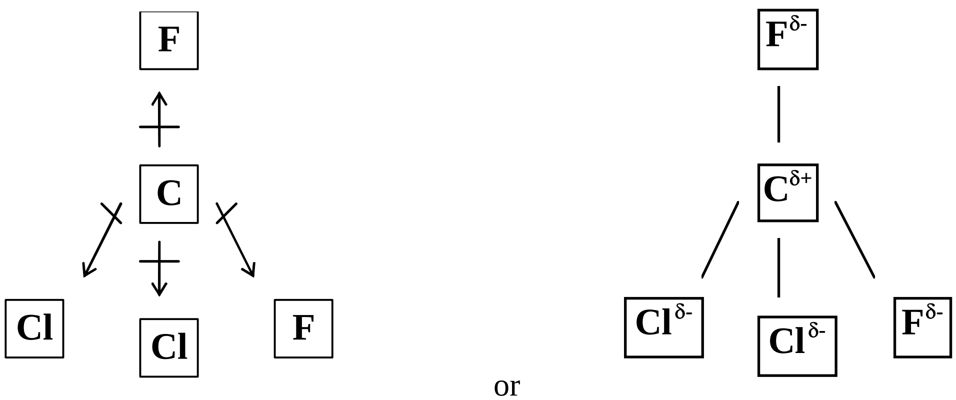
$$= 326 \times 10^3/6.02 \times 10^{23} = 5.41 \times 10^{-19} \text{ J/bond}$$

photon will break this bond if $E_{ph} > E_{bond} \Rightarrow$ critical λ is

$$\lambda = \frac{hc}{E_{bond}} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{5.41 \times 10^{-19}} = 3.66 \times 10^{-7} \text{ m}$$

which lies in the u.v. part of the electromagnetic spectrum.

(b) Draw the Lewis structure of Freon 12 and indicate the polarities of each bond within this compound.



(c) C-Cl $\Delta\chi = 0.61 \rightarrow$ ~9% ionic character
C-F $\Delta\chi = 1.43 \rightarrow$ ~40% ionic character