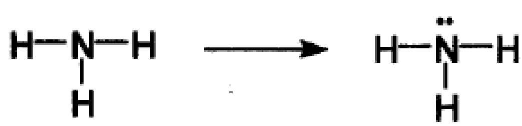
Chapter 7 - Covalent Bonding
Text Problems: 2,4,8,20,24,28,30,34,38,42,46,52,67,69,73

2. *Refer to Section 7.1 and Examples 7.1 and 7.2.*

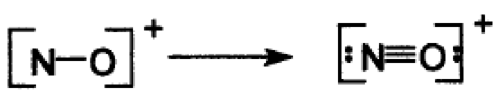
Add up the total number of valence electrons. Draw the skeletal structure, then add the electrons (remember that each bond represents two electrons).

a. N: 5 valence electrons
3H: 3 x 1 valence electrons
total: 8 electrons



b. Kr: 8 valence electrons
2F: 2 x 7 valence electrons
total: 22 electrons

c. N: 5 valence electrons
O: 6 valence electrons
+1: -1 valence electron
total: 10 electrons

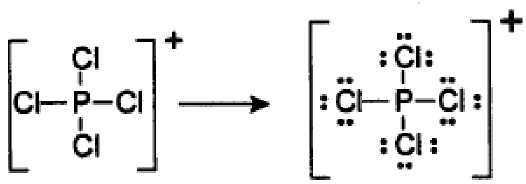


d. Br: 7 valence electrons
2O: 2 x 6 valence electrons
-1: 1 valence electron
total: 20 electrons

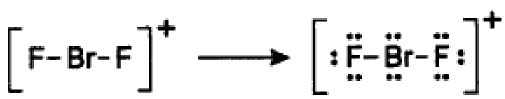
4. *Refer to Section 7.1 and Examples 7.1, 7.2, and 7.4.*

Add up the total number of valence electrons. Draw the skeletal structure, then add the electrons (remember that each bond represents two electrons).

a. P: 5 valence electrons
4Cl: 4 x 7 valence electrons
+1: -1 valence electron
total: 32 electrons

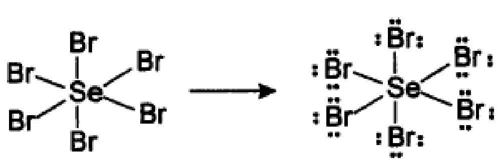


b. Br: 7 valence electrons
2F: 2 x 7 valence electrons
+1: -1 valence electron
total: 20 electrons



c. 3I: 3 x 7 valence electrons
-1: 1 valence electron
total: 22 electrons

d. Se: 6 valence electrons
6Br: 6 x 7 valence electrons
total: 48 electrons



8. *Refer to Section 7.1 and Example 7.1.*

Add up the total number of valence electrons. Draw the skeleton structure, then add the electrons (remember that each bond represents two electrons). Subtract from the number of valence electrons those used for the skeleton structure. Then give each atom an octet (except H) by assigning to it an unshared pair or a multiple bond.

C: 4 valence electrons
O: 6 valence electrons
H: 1 valence electron
+1: -1 valence electron
total: 10 electrons

$[H-C-O]^+$ Valence electrons left: 10 – 4 = 6

In order to give C and O octets, 5 unshared pairs of electrons (10 electrons) are needed. Since there are only 6 electrons, the octets must be filled using multiple bonds between C and O (recall that H has all the electrons it needs around it).

$[H-C\equiv O:]^+$

Note that a double bond between the C and O atoms would not allow C to have an octet.

20. Refer to Section 7.1.

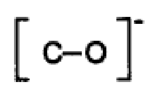
Parts b-d have odd numbers of electrons. Consequently, the final structures will have an unpaired electron.

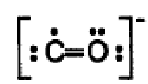
a. Be: 2 valence electrons
2H: 2 x 1 valence electrons
total: 4 electrons

H-Be-H

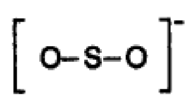
The skeletal structure is the final Lewis structure.

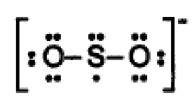
b. C: 4 valence electrons
O: 6 valence electrons
-1: 1 valence electron
total: 11 electrons



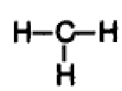


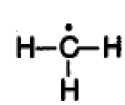
c. S: 6 valence electrons
O: 2 x 6 valence electrons
-1: 1 valence electron
total: 19 electrons





d. C: 4 valence electrons
3H: 3 x 1 valence electrons
total: 7 electrons

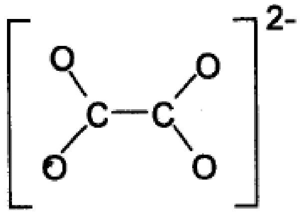




24. *Refer to Section 7.1 and Example 7.3.*

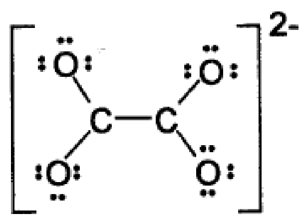
a. Add up the total number of valence electrons. Draw the skeleton structure, then add the electrons (remember that each bond represents two electrons). Subtract from the number of valence electrons those used for the skeleton structure. Then give each atom an octet (except H) by assigning to it an unshared pair or a multiple bond.

2C: 2 x 4 valence electrons
4O: 4 x 6 valence electrons
-2: 2 x 1 valence electrons
total: 34 electrons



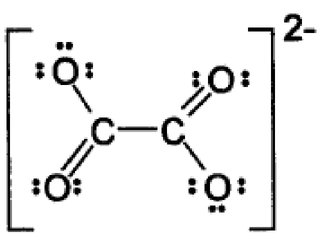
Valence electrons left: 34 – 10 = 24

Try to fill the octet of each atom using unshared pairs. There are 12 unshared pairs available.

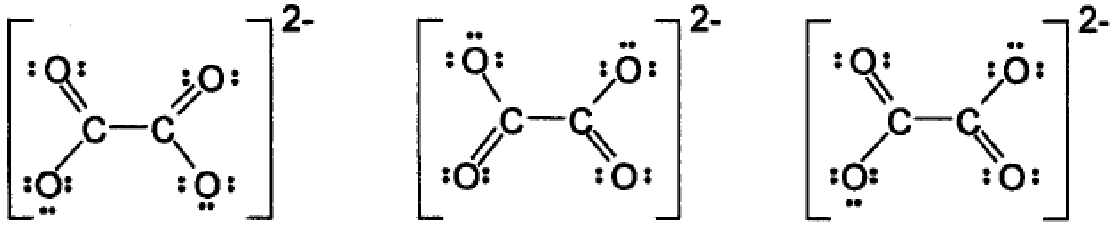


Notice that there are not enough unshared pairs to give carbon an octet.

To complete the octets, move a pair of electrons from each of two oxygens to form (double) bonds between the carbon and oxygen.



b. The three resonance structures are drawn by moving the double bonds and the unshared pairs so that each atom still has an octet.

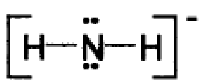


c. Resonance forms differ only in distribution of electrons, not in arrangement of atoms. Thus, the structure given in c is **not** a resonance form.

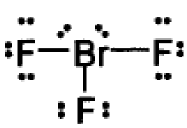
28. Refer to Section 7.1 and Table 7.2.

Draw the Lewis structure. Then apply the formula: $C_f = e_{valence} - (e_{unshared} + ½(e_{bonding}))$
[formal charge = valence electrons - (unshared electrons + ½(bonding electrons))]
Note that this is the formula given in the text as: $C_f = X - (Y + Z/2)$.

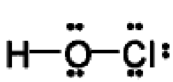
a. N: 5 valence electrons
2H: 2 x 1 valence electrons
-1: 1 valence electron
total: 8 electrons
$C_f = 5 - (4 + ½(4)) = -1$



b. Br: 7 valence electrons
3F: 3 x 7 valence electrons
total: 28 electrons
$C_f = 7 - (4 + ½(6)) = 0$



c. H: 1 valence electron
O: 6 valence electrons
Cl: 7 valence electrons
total: 14 electrons
$C_f = 6 - (4 + ½(4)) = 0$



30. *Refer to Section 7.2, Examples 7.5 and 7.6, Figure 7.5, and Table 7.3.*

In both structures, all 3 oxygen atoms have a formal charge of −1. $C_f = 6 - (6 + ½(2)) = -1$. Therefore, the formal charges on the sulfur atoms will determine the better structure.

Structure I
Central S: $C_f = 6 - (2 + ½(6)) = +1$
Chain S: $C_f = 6 - (4 + ½(4)) = 0$

Structure II
Central S: $C_f = 6 - (0 + ½(8)) = +2$
Terminal S: $C_f = 6 - (6 + ½(2)) = -1$

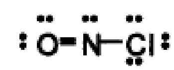
Structure I is the better choice of structures since the formal charges on those sulfur atoms are as close to zero as possible.

34. *Refer to Section 7.2, Examples 7.5 and 7.6, Figures 7.4 and 7.5, and Table 7.3.*

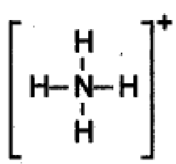
Draw the Lewis structure of the compound and determine the number of bonded groups and the number of electron pairs. Then use Table 7.3 to assign the geometry.

a. NNO ⇒ 

2 bonded groups, no electron pairs, thus AX_2 and **linear**.

b. ONCl ⇒ 

2 bonded groups, one electron pair, thus AX_2E and **bent**.

c. NH_4^+ ⇒ 

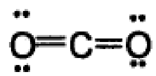
4 bonded groups, no electron pairs, thus AX_4 and **tetrahedron**.

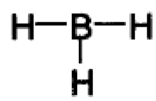
d. O_3 ⇒ 

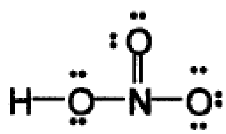
2 bonded groups, one electron pair, thus AX_2E and **bent**.

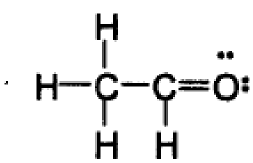
38. *Refer to Section 7.2, Figure 7.5, and Table 7.3.*

Draw the Lewis structure, determine the geometry and, from that, the ideal bond angles.

a.  AX_2, linear **180°**

b.  AX_3, triangular planar **120°**

c. 
O(left): AX_2E_2, bent **109.5°**
N: AX_3, triangular planar **120°**

d. 
C(left): AX_4, tetrahedron **109.5°**
C(right): AX_3, triangular planar **120°**

42. Refer to Section 7.2.

Draw the Lewis structure for the molecule. Then determine the geometry of the indicated atom and from that, the bond angles.

1	AX_3	bent	**120°**
2	AX_2E_2	bent	**109.5°**
3	AX_3	triangular planar	**120°**

46. Refer to Section 7.2 and Example 7.7.

First determine if the central atom has an octet. Then consider the electronegativity of the atoms to determine if there are dipoles. Then consider the geometry of the molecule to determine if there is a net dipole.

All 4 molecules have octets about the central atom.

a. There is only one dipole, between the central N and the O. Thus, there is a net dipole and **the molecule is a dipole.**

b. There are 2 dipoles, between N-O and N-Cl. Since this molecule is bent, there is a net dipole, and **the molecule is a dipole.**

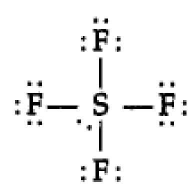
c. There are 4 dipoles, between each of the N-H bonds. Since the molecule is tetrahedron, the 4 dipoles cancel each other out; there is no net dipole, so **the molecule is not a dipole.**

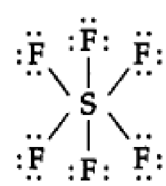
d. Since all the atoms are identical, there are no dipoles and one would thus assume there is no net dipole. However, a dipole depends only on an unsymmetrical distribution of electrons. Since this molecule is bent, that criterion is met, and **the molecule is a dipole.**

52. Refer to Section 7.4, Table 7.4, Example 7.9, and Problem 34 (above).

Recall that the total number of groups (bonded atoms and electron pairs) around the central atom is equal to the number of orbitals that hybridized. Furthermore, the sum of the superscripts in the hybrid orbital notation gives the total number of hybrid orbitals.

a.	NNO	AX_2	2 groups	sp
b.	ONCl	AX_2E	3 groups	sp^2
c.	NH_4^+	AX_4	4 groups	sp^3
d.	O_3	AX_2E	3 groups	sp^2

67. (b) 

(d) 

69. (a) 20 sigma, 2 pi

(b) 12

(c) 1 = 109.5°, 2 = 109.5°, 3 = 120°

(d) A = sp^3, B = sp^2, C = sp^2

73. (a) AX_4E_2 ; square planar

(b) AX_5 ; triangular bipyramidal

(c) AX_2E ; bent

(d) AX_3E_2 ; T shaped

(e) AX_2E_2 ; bent

(f) AX_5E ; square pyramidal