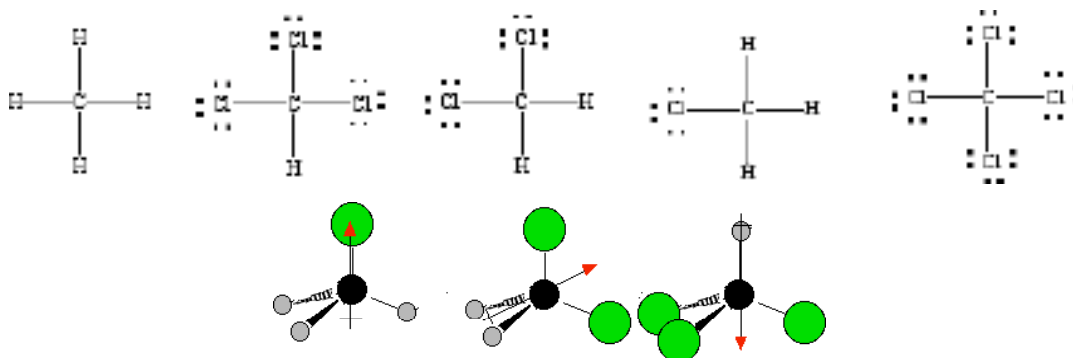


- 9.48 Determine the Lewis structures using standard procedures. In each case, four electron pairs are used in the bonding framework, and all remaining electrons are placed on the outer Cl atoms. The inner carbon atom in each of these molecules has $SN = 4$ and tetrahedral geometry. CH_4 and CCl_4 have four identical bonds, so these molecules have no dipole moment. CH_3Cl , CH_2Cl_2 , and $CHCl_3$ have outer atoms with different electronegativities, so these three molecules are asymmetric and have dipole moments.



- 9.78 The electronegativity of oxygen is the largest (3.5) among the elements involved in these chemical bonds. Thus, the element with the smallest electronegativity will have the largest bond polarity with oxygen; the element with the largest electronegativity will have the smallest bond polarity: $N-O < Br-O < C-O = S-O < O-H$

- 9.54 The determinants of bond length, in order of importance, are principal quantum number of the valence orbitals, bond order, and bond polarity. Here, $H-F$ is shortest because it involves an $n = 1$ orbital, $Br-Br$ is longest because it forms from two $n = 4$ orbitals, and $Cl-Cl$ is next because it forms from two $n = 3$ orbitals. Of the two bonds involving an $n = 2$ and an $n = 3$ orbital, $P=O$ is shorter than $O-Cl$ because it is a multiple bond:



- 9.56 Bond strengths, like bond lengths, depend on principal quantum number, bond order, and bond polarity, but the correlation is not as strong as for bond lengths, so tabulated values must be consulted. Here are the values from Table 6-2 of your textbook, listed in order of increasing bond energy:

Bond	$Sn-Sn <$	$Si-Si <$	$C-Si <$	$C-C <$	$H-C$
Energy (kJ/mol)	145	225	300	345	415

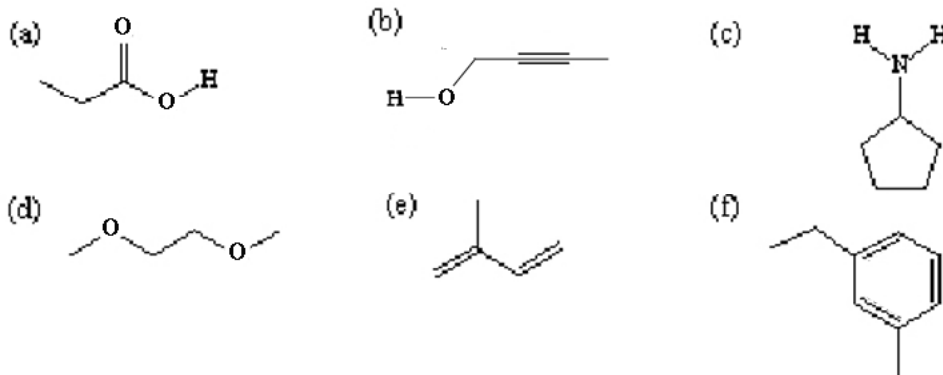
In this series, the differences in bond energy arise from the fact that lower n -value valence orbitals overlap better than higher n -value valence orbitals:

Sn has $n = 5$, Si has $n = 3$, C has $n = 2$, and H has $n = 1$.

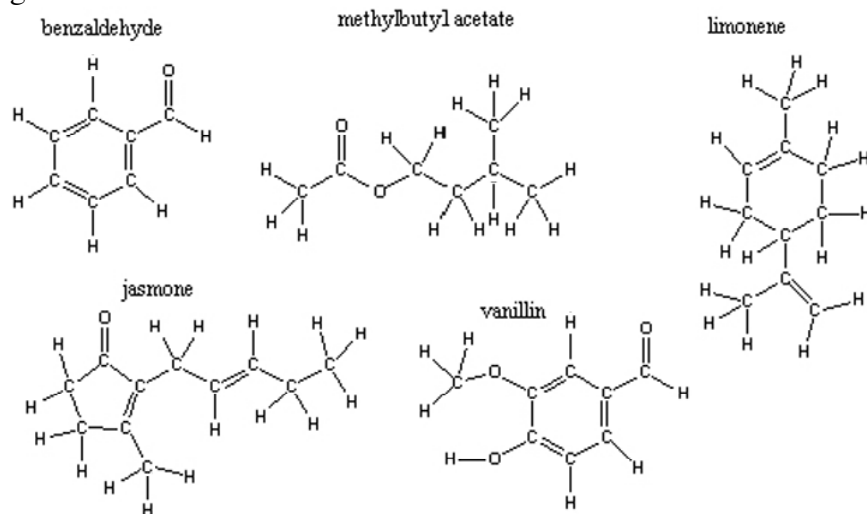
- 9.72 The determinants of bond length, in order of relative importance, are principal quantum number of the valence orbitals, bond order, and bond polarity. The bonds found in these molecules are $H-O$, $H-N$, $C=O$, and $O-Cl$. Of these, $H-O$ and $H-N$ are shorter than the

others because they form from an $n = 1$ orbital; H–O is shorter than H–N because it is a more polar bond. C≡O is shorter than O–Cl because O–Cl forms from an $n = 3$ orbital (C≡O is also much higher in bond order, 3, than O–Cl, 1).

- 3.6 To convert a structural formula into a line structure, remove all –H connections to carbon atoms and remove all C atom labels:



- 3.60 To convert a line structure into a structural formula, place a C atom at the end of each line and at each line intersection. Then add enough –H connections to give each C atom four connections. From the structural formula, determine the chemical formula by counting and calculate the molar mass from numbers of atoms and atomic molar masses:



- (a) benzaldehyde, C_7H_6O :

$$MM = 7(12.01 \text{ g/mol}) + 6(1.008 \text{ g/mol}) + 16.00 \text{ g/mol} = 106.12 \text{ g/mol}$$

- (b) methylbutyl acetate, $C_7H_{14}O_2$:

$$MM = 7(12.01 \text{ g/mol}) + 14(1.008 \text{ g/mol}) + 2(16.00 \text{ g/mol}) = 130.18 \text{ g/mol}$$

- (c) jasmone, $C_{11}H_{16}O$:

$$MM = 11(12.01 \text{ g/mol}) + 16(1.008 \text{ g/mol}) + 16.00 \text{ g/mol} = 164.24 \text{ g/mol}$$

- (d) limonene, $C_{10}H_{16}$, $MM = 10(12.01 \text{ g/mol}) + 16(1.008 \text{ g/mol}) = 136.23 \text{ g/mol}$

- (e) vanillin, $C_8H_8O_3$:

$$MM = 8(12.01 \text{ g/mol}) + 8(1.008 \text{ g/mol}) + 3(16.00 \text{ g/mol}) = 152.14 \text{ g/mol}$$

10.10 The name of a hybrid orbital set includes the letter of the atomic orbitals, and the number of each type, used to make the set: (a) sp^2 ; (b) sp^3d ; and (c) sp^3 .

10.14 The steric number of an inner atom uniquely determines its hybridization. Use the Lewis structure of the molecule to find steric numbers: (a) SN = 3, sp^2 hybrids; (b) SN = 6, sp^3d^2 hybrids; (c) SN = 5, sp^3d hybrids; and (d) SN = 4, sp^3 hybrids.

**Don't forget those Chapter 9 problems and class examples where you drew the Lewis structure and predicted the molecular shape. You should also be able to state the hybridization.*

10.44 We can determine hybridizations directly from line structures: Each C atom with no double bonds has SN = 4 and sp^3 hybrids can describe the bonding. A C atom with one double bond has SN = 3 and sp^2 hybridization:

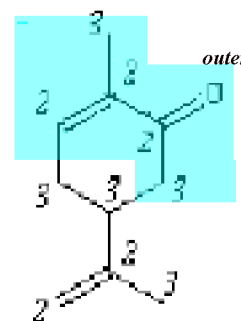
(a) Hybridization is as shown on the line drawing

(3 = sp^3 , 2 = sp^2).

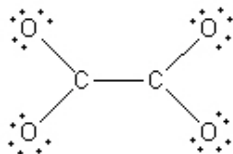
(b) There are 3 π bonds.

(c) Two π bonds are on adjacent atoms, so as in butadiene there are four electrons in the extended π system.

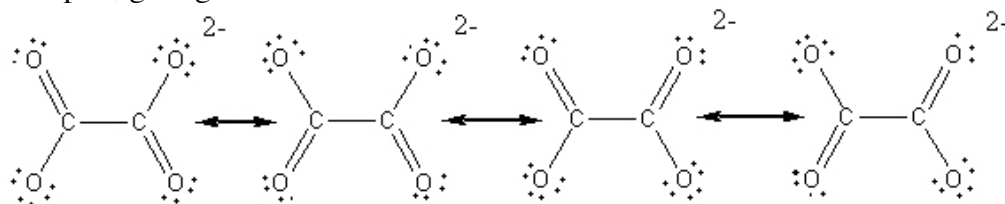
(d) The four atoms with double bonds and the three atoms bonded directly to them all lie in the same plane.



10.46 A description of bonding and geometry always starts with a Lewis structure and a count of bonds and non-bonding pairs around inner atoms. There are $2(4) + 4(6) + 2 = 34$ electrons. The provisional structure has three pairs of electrons associated with each carbon atom:



Each C atom has one double bond to complete its octet, and either O atom can provide the electron pair, giving four resonance structures:



Each carbon atom has SN = 3, so sp^2 hybrids overlapping with oxygen $2p$ orbitals describe the σ bonds. The geometry around each carbon atom is trigonal planar. All six atoms contribute p orbitals to the π system, which extends over the entire structure.

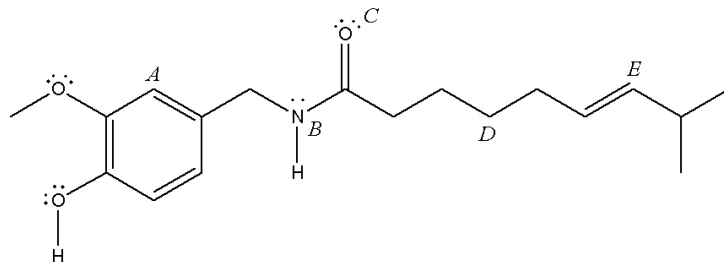
10.62 The formula of capsaicin reveals that it contains C, H, O, and N atoms. From the line structure below, those with only single bonds, have sp^3 hybridization, and tetrahedral geometry. Those with a double bond, have sp^2 hybridization, and trigonal planar geometry.

(a) There are five π bonds in this molecule.

(b) A: sp^2 for the σ bonds, p for the π bond; B: sp^3 ; C: sp^2 for the σ bonds, p for the π bond; D: sp^3 ; E: sp^2 for the σ bonds, p for the π bond

(c) A: $\sim 120^\circ$; B: $\sim 109.5^\circ$; C: $\sim 120^\circ$; D: $\sim 109.5^\circ$; E: $\sim 120^\circ$

(d)



***Solutions to other Chapter 9 Suggested Problems not in this document were given as handouts in class.*