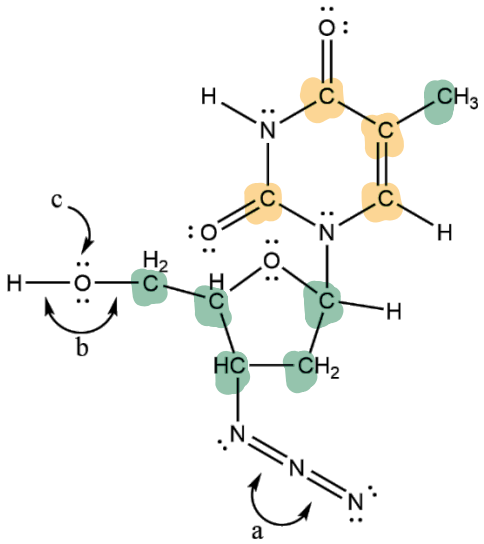
CHEM 103
R&R 16
21 June 2024
Adapted from a 28 June 2021 document

1. One of the first drugs to be approved for use in treatment of HIV/AIDS was azidothymidine (AZT). The complete Lewis structure of AZT is shown below:



a. How many carbon atoms are sp^3 hybridized? 6

b. How many carbon atoms are sp^2 hybridized? 4

c. Which atom is sp hybridized? middle N

d. How many σ bonds are there in the molecule? 33

e. How many π bonds are there in the molecule? 5

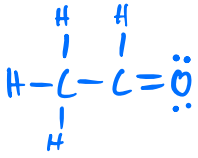
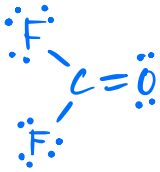
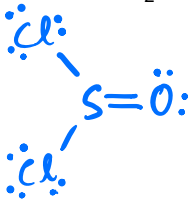
f. What is the bond angle marked (a)? 180°

g. What is the bond angle marked (b)? < 109.5°

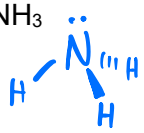
h. What is the hybridization of atom (c)? sp^3

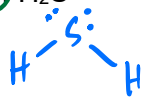
i. What is the bond order of the central N in (a)? 2 ← 4 bonds / 2 connections

2. Each of the following molecules contains at least one multiple (double or triple) covalent bond. Give a plausible Lewis structure for:

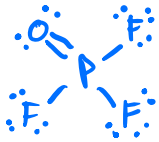
OCS	CH_3CHO	COF_2	$SOCl_2$	C_2H_2
				

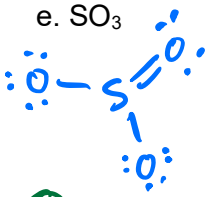
3. Which of the following molecules would you expect to be polar?

a. NH_3 

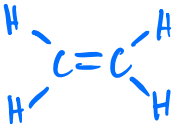
b. H_2S 

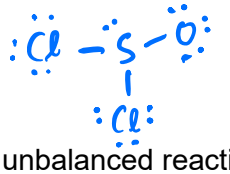
c. OCS 

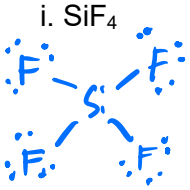
d. POF_3 

e. SO_3 

f. CS_2 

g. C_2H_4 

h. $SOCl_2$ 

i. SiF_4 

4. Estimate ΔH_{rxn} for the following unbalanced reaction using bond dissociation enthalpy values.

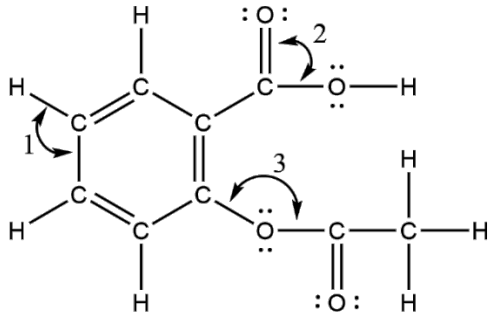
$$CH_4\,(g) + \tfrac{1}{2}O_2\,(g) \rightarrow CH_3OH\,(g)$$

$$\Delta H_{rxn} = \left(4\,BDE[C\text{-}H] + \tfrac{1}{2}BDE[O{=}O]\right) - \left(3\,BDE[C\text{-}H] + BDE[C\text{-}O] + BDE[O\text{-}H]\right)$$

$$= \left(4 \cdot 413\,\tfrac{kJ}{mol} + \tfrac{1}{2} \cdot 498\,\tfrac{kJ}{mol}\right) - \left(3 \cdot 413\,\tfrac{kJ}{mol} + 358\,\tfrac{kJ}{mol} + 463\,\tfrac{kJ}{mol}\right)$$

$$= -159\,\tfrac{kJ}{mol}$$

5. Acetylsalicylic acid, better known as aspirin, has the following Lewis structure:



a. What are the approximate values of the bond angles labeled 1, 2, and 3?

1: 120° 2: 120° 3: < 109.5°

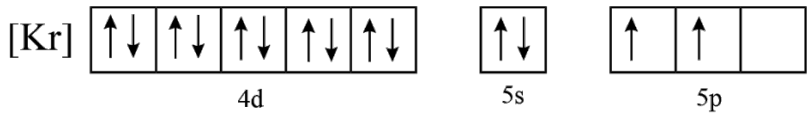
b. What hybrid orbitals are used about the central atom in each of these angles?

1: sp^2 2: sp^2 3: sp^3

c. How many σ bonds are in the molecule? How many π bonds?

21σ, 5π

6. What is a possible set of quantum number for an unpaired electron in the orbital box diagram below?



a. n = 1, l = 1, m_l = -1, m_s = +½

b. n = 4, l = 2, m_l = -1, m_s = -½

c. n = 5, l = 2, m_l = -2, m_s = +½

d. n = 5, l = 0, m_l = 0, m_s = -½

e. n = 5, l = 1, m_l = -1, m_s = +½

14 + 36 = 50

What element is this? Sn (tin)

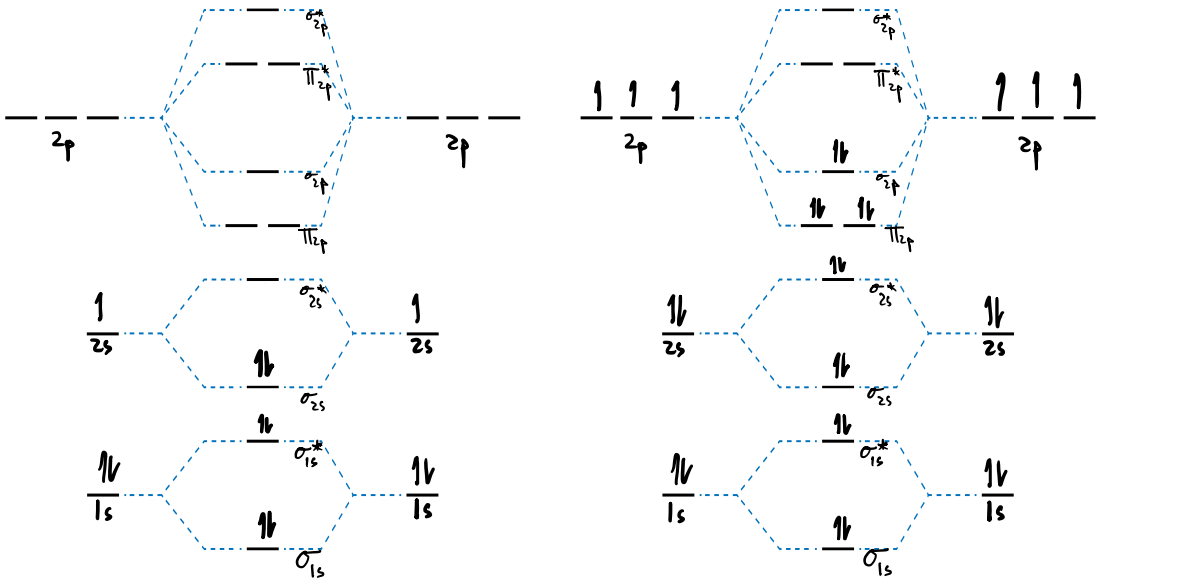
7. Using the molecular orbital (MO) model:

a. Label each orbital and fill in the MO diagram.

b. Calculate each bond order.

Li_2 bond order: $\frac{4-2}{2} = 1$

N_2 bond order: $\frac{10-4}{2} = 3$



(Diagram sourced from https://ch301.cm.utexas.edu/imfs/#mo/mo-theory-all.php)