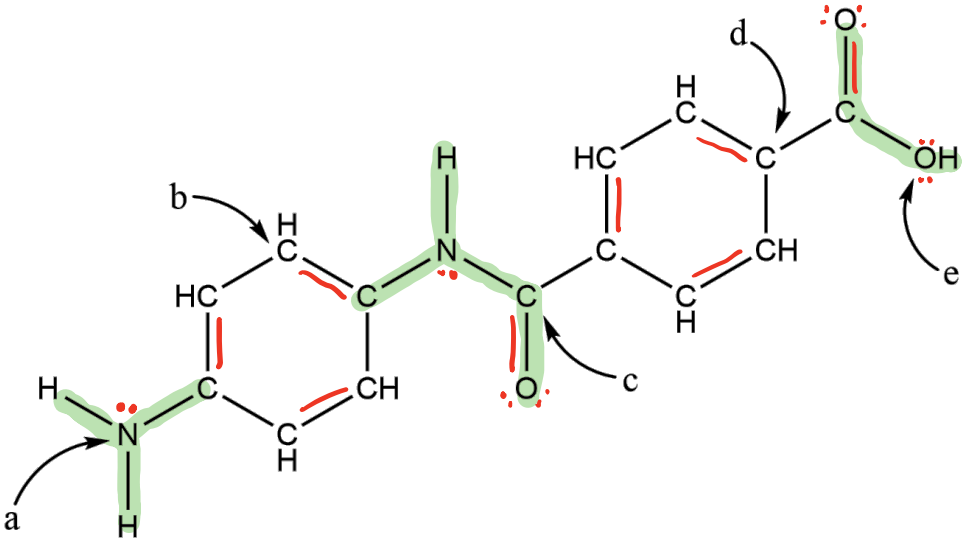
CHEM 103
R&R 15
20 June 2024
Adapted from a 25 June 2021 document

1.




a. Complete the structure above by adding bonds and lone pairs. Every atom will have a complete octet and formal charge of zero. What is the hybridization of the atoms marked (a) through (e)?

a: $sp^3$ b: $sp^2$ c: $sp^2$ d: $sp^2$ e: $sp^3$

b. How many σ bonds are in the structure above? How many π bonds?

32 σ, 8 π

c. Circle all of the polar bonds. highlighted

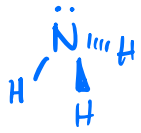
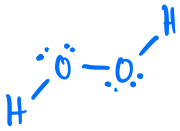
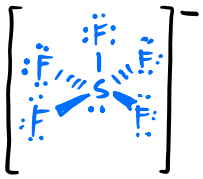
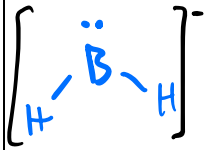
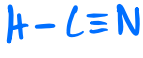
d. What are the bond angles at atoms (a) through (e)?

a: $<109.5^\circ$ b: $120^\circ$ c: $120^\circ$ d: $120^\circ$ e: $<109.5^\circ$

2. Complete the following table:

| Number of regions of high $e^-$ density | Electron pair geometry name | Hybridization | Angle btwn electron density regions | Total hybrid orbitals | Number of p orbitals left over |
|---|---|---|---|---|---|
| 2 | linear | sp | $180^0$ | 2 | 2 |
| 3 | trig. planar | $sp^2$ | $120^0$ | 3 | 1 |
| 4 | tetrahedral | $sp^3$ | $109.5^0$ | 4 | 0 |

3. Fill out the following table:

| Name & Lewis structure | 3D Structure | Electron pair geometry name | Molecular geometry name | Hybridization of each central atom | Polarity of molecule |
|---|---|---|---|---|---|
| Ammonia |  | tetrahedral | trig. pyramidal | $sp^3$ | polar |
| $H_2O_2$ |  | tetrahedral | bent | $sp^3$ | polar |
| $SF_5^-$ |  | octahedral | square pyramidal | $sp^3d^2$ | polar |
| $BH_2^-$ |  | trig planar | bent | $sp^2$ | polar |
| HCN |  | linear | linear | sp | polar |

4. Balance the following reaction. Then, using bond dissociation enthalpies from the book, lecture slides, or an online source, calculate the bond dissociation enthalpy of the O-F bond.

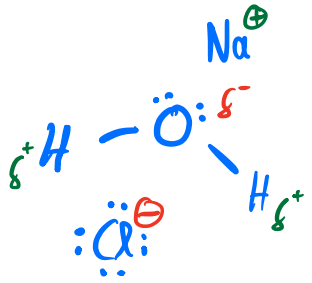
$$OF_2\,(g) + H_2O\,(g) \rightarrow O_2\,(g) + 2\,HF\,(g) \qquad \Delta H_{rxn} = -318\ kJ/mol$$

$$\Delta H_{rxn} = \left(2\ BDE[O\text{-}F] + 2\ BDE[O\text{-}H]\right) - \left(2\,BDE[H\text{-}F] + BDE[O{=}O]\right)$$

$$-318\ \frac{kJ}{mol} = \left(2 \cdot BDE[O\text{-}F] + 2 \cdot 463\ \frac{kJ}{mol}\right) - \left(2 \cdot 565\ \frac{kJ}{mol} + 498\ \frac{kJ}{mol}\right)$$

$$384\ \frac{kJ}{mol} = 2 \cdot BDE[O\text{-}F] \Rightarrow BDE[O\text{-}F] = 192\ \frac{kJ}{mol}$$

5. Draw a likely spatial orientation of a single water molecule with a single molecule of NaCl.




6. True or False:

a. The principal quantum number (n) associated with an f orbital must be ≥4. True

b. For an electron to go from a lower energy level to a higher energy level, a photon must be absorbed. True

c. The freezing of water is an endothermic process. False

d. The first ionization energy of Li is less than the second ionization energy of Li. True

e. The electronegativity of H is less than that of Mg. False

f. Cation are always larger than the neutral atom of the same element. False

7. Name three atoms or ions that are described by the electron configuration: $[Ar]4s^2 3d^{10} 4p^5$

$Br$, $Se^-$, $Kr^+$

# Explanations for #6:

a) whenever $n$ increases, the maximum value of $l$ increases too.

$n=1 \Rightarrow$ max. $l=0 \Rightarrow$ s orbital
$n=2 \Rightarrow$ max. $l=1 \Rightarrow$ p orbital
$n=3 \Rightarrow$ max. $l=2 \Rightarrow$ d orbital
$n=4 \Rightarrow$ max. $l=3 \Rightarrow$ f orbital

And so on.

b) photons mediate changes in energy levels for electrons. If an electron moves up an energy level, it must have gotten that energy from a photon.

c) When water freezes, its internal energy is decreasing $\Rightarrow$ the energy of its surroundings is increasing $\Rightarrow$ exothermic.

d) Lithium only has one valence electron. Ionizing a second electron would thus be removing a core electron $\Rightarrow$ VERY energy intensive, and much greater than losing a valence electron.

e) From a table: $\chi_H \approx 2.1$, $\chi_{Mg} \approx 1.2$. In general, hydrogen is more electronegative than metals, as it can form hydrides (compounds with $H^-$)

f) Cations have fewer valence electrons repelling each other and making the electron cloud large. Cations are smaller than the neutral atom.