Assignment 11

Due Wednesday, December 1

Topics: This week, we will return to a discussion of atomic orbitals, and how the description of electron probability that they provide can be reconciled with the molecular shapes we observe. The orientations of the bonds within the three-dimensional molecules, as described by VSEPR, do not match the spatial orientations of the atomic orbitals for the component atoms. This observation suggests that the orbitals for atoms within molecules differ from the orbitals for free atoms. We will introduce the concept of hybridization, in which new atomic orbitals are constructed from the hydrogen-like orbitals for free atoms, to provide an orbital description of bonding that is consistent with the observations of the VSEPR model.

Reading & Problems: Zumdahl, 6th edition

Date	Lecture	Reading	Problems
Wednesday, 11/17	Lewis structures, resonance, formal charge	Sections 13.6, 13.9 – 13.12	Ch. 13: #52, 54, 72, 74, 98
Friday, 11/19	VSEPR, Molecular dipoles	Section 13.13	Ch. 13: #76, 80
Monday, 11/29	Molecular Dipoles, Hybrid orbitals	Section 14.1 thru p. 668 (sp hybridization)	Ch. 13: #82 (answer only for #80) and 90
Wed. 12/2	Hybrid orbitals	Sections 14.1, pp. 668 - 673	

Challenge Problem

1. Sulfur dioxide (SO_2) and ozone (O_3) are both colorless gaseous pollutants with characteristic odors. SO_2 is responsible for the characteristic smell of fireworks or a struck match, and O_3 is responsible for the characteristic smell after a lightning storm.
   a. There are three reasonable resonance structures that can be drawn for SO_2. Draw and evaluate these three resonance structures; in other words, identify which resonance structure(s) the real molecule most closely resembles, providing justification for your answer.
   b. Predict the shape (including bond angle) of SO_2.
2. Sulfur dioxide (SO_2) can be oxidized by oxygen gas to form sulfur trioxide (SO_3), which dissolves in water to form sulfuric acid (H_2SO_4). It is this process by which the SO_2 formed as a byproduct from the burning of coal leads to acid rain.
   a. There are several resonance structures that can be drawn for SO_3. Draw and evaluate all reasonable resonance structures for SO_3.
   b. Predict the shape (including bond angles) of SO_3.

c. Provide an explanation for the observation that the analogous oxygen compound, O_4 (in which there is an O atom in place of the S atom of SO_3), does not exist.

3. Nitrogen dioxide (NO_2) is a gaseous pollutant that contributes to the brown color of urban smog.

   a. Draw and evaluate all reasonable resonance structure(s) for NO_2.

   b. Predict the shape (including bond angle) of NO_2.

   c. Explain the observation that NO_2 is a highly reactive species.

   d. Draw and evaluate all reasonable resonance structure(s) for NO_2^+.

   e. Compare the length of a nitrogen–oxygen bond within NO_2^+ to the length of a nitrogen–oxygen bond within NO_2.