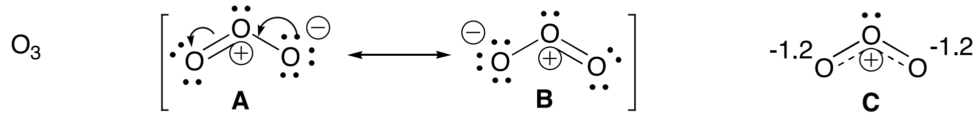
Resonance Structures (Section 1-9)
Sometimes a single Lewis structure does not provide an adequate picture.

Example: O_3 (ozone)



2 Resonance Forms

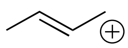
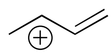
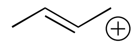
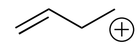
Actual Species Is a Hybrid of the Resonance Forms

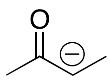
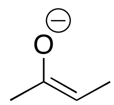
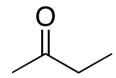
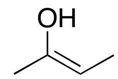
Notes/observations:

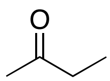
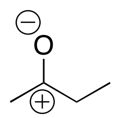
1. Neither form **A** nor **B** can avoid formal charges.
   - The majority of resonance situations have some formal charge involvement
2. The real molecule is hybrid: see picture **C**
   - The central oxygen has + charge
   - Each of the outside oxygens is -1/2
   - Both of the bonds to the outside oxygens are equal in length/strength
   - The actual length/strength of the oxygen-oxygen bonds reflect 1.5 bonds (shorter and stronger than single bonds; longer and weaker than double bonds)
3. Why not just draw the hybrid?
   - Hard to do, without first working through resonance structures first.
   - Hard to keep track of the electrons, which is essential for understanding reactivity
4. When are Two Structures related as Resonance Structures?
   - Atoms must be connected in exactly the same way. Resonance forms differ **only in the placement of electrons.**
   - If two Lewis structures have the same atomic connectivity, but differ **only** in the placement of some electrons, they are related as resonance structures.
   - If the placement/connectivity of atoms differ, then the two structures are not resonance structures (they may perhaps be related as "isomers", see later.)
   - KEY: FOR RESONANCE STRUCTURES, ELECTRONS MOVE BUT ATOMS DO NOT MOVE. IF ATOMS MOVE, YOU DON'T HAVE RESONANCE STRUCTURES
   - Note: The real molecule is represented by the hybrid, and electrons are not actually jumping back and forth.
5. Resonance, when it exists, involves the **delocalization** of electrons and charge
   - In ozone, instead of one of the outside oxygens getting stuck with a full negative charge, that negative charge is shared with the other outside oxygen, and both have a more manageable -1/2 charge
   - This delocalization of electrons/charge is stabilizing.
   - **KEY: RESONANCE IS STABILIZING**
6. Resonance, when it exists, always involves electrons in double bonds and/or lone pairs (π electrons)
7. One of the most frequent resonance situations we'll see is when you a charged atom attached to a double bonded atom ("allylic" situation")
8. When resonance structures are equal in stability, the hybrid is the average of the resonance forms
9. When resonance structures are unequal, the more stable structure dominates the hybrid
   - Ranking Stability:
   - More bonds → more stable (but don't exceed octet rule!). (Priority rule)
   - Bonds being equal (tiebreaker rule): **negative charge** is better on **more electronegative atom**; **positive charge** is better on **less electronegative atom**

Resonance Problems

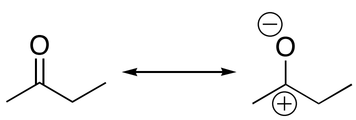
1. Which of the following are related as resonance structures?

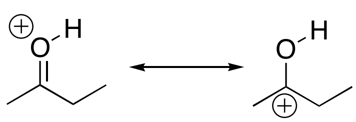





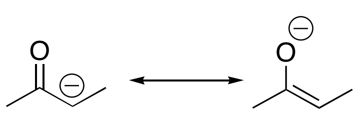





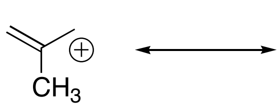
2. Which Resonance Structure is Better and would make a more than 50% contribution to the actual hybrid? Why, bonds or electronegativity?

a. 

b. 

c. 

3. Draw a resonance structure for the following

a. 

b.