

Lewis Structures and Resonance

UCI Chem 51A

Dr. Link

Goals

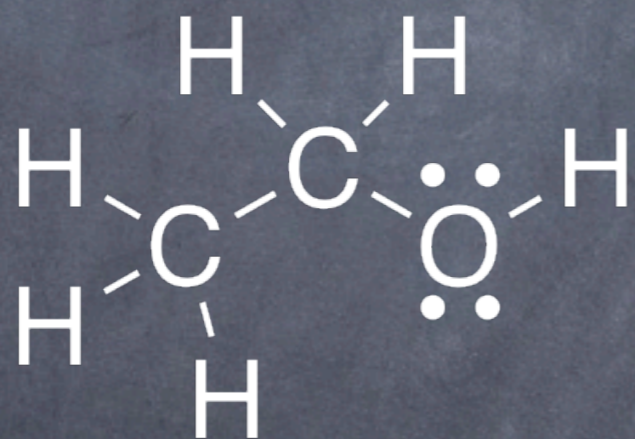
- After this lesson you should be able to:
 - 1. Explain why Lewis structures are integral to organic chemistry.
 - 2. Draw valid Lewis structures.
 - 3. Count formal charge.
 - 4. Explain the need for resonance theory.
 - 5. Explain what is a resonance structure and what is not.
 - 6. Draw valid resonance structures.
 - 7. Properly use curved arrow notation.
 - 8. Identify major and minor resonance contributors.
 - 9. Draw the resonance hybrid for a structure.

Lewis Structures: Quick Review

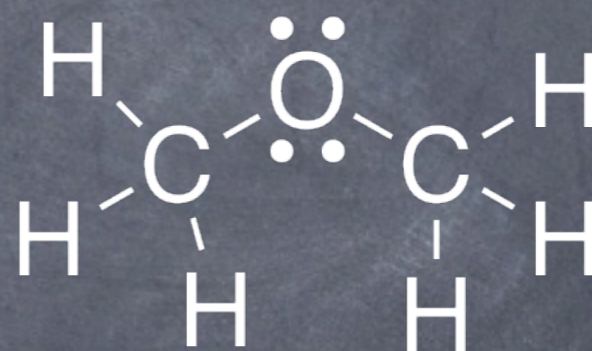


- Lewis structures are representations of molecules that depict bonds and lone pairs.
- Why are structures needed?
 - In gchem, you used mainly formulas.

One Formula, Many Structures



ethanol



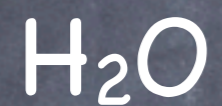
dimethyl ether

1 formula can = multiple structures!

How to Draw Lewis Structures:

- 1. Count valence electrons. (As you become more comfortable drawing structures you can sometimes skip this step, but occasionally double-check!)
- 2. Arrange atoms. Organic formulas will usually give you an idea of how.
- 3. Draw in single bonds. Distribute lone pairs. Count your electrons.
- 4. Check for octets. IF NEEDED add double or triple bonds. (Don't get double-bond-happy!)
- 5. Maximize octets, minimize formal charge. (More on this later.)

Lewis Structure Examples

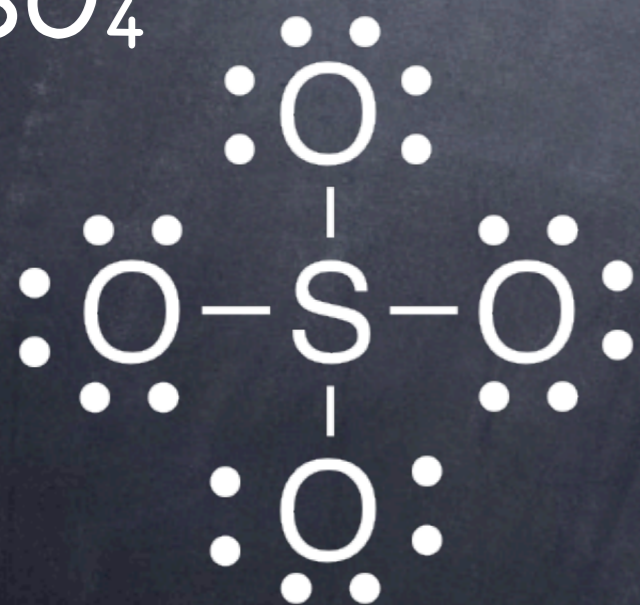
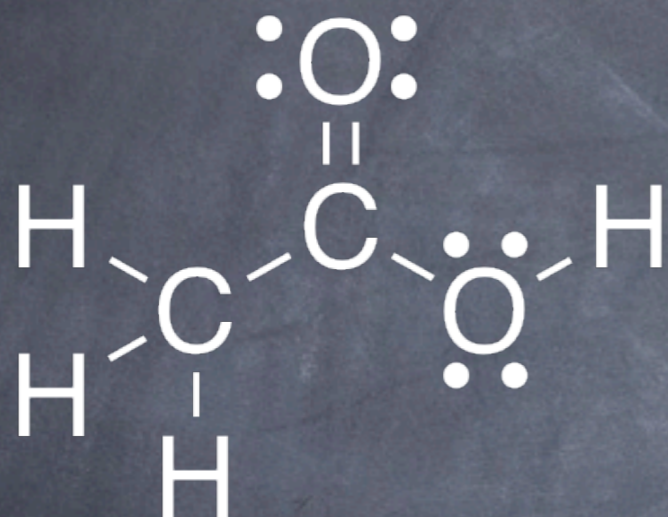


Electron Accounting

Methods: Formal Charge

- Formal charge lets us know if an atom is electron-rich or electron-poor! (Important for reactions later!)
- Counting formal charge is different than counting for octet rule! Be careful!
- Counting rules:
 - 1. Count formal charge for individual atoms in a structure.
 - 2. Non-bonding pairs count as 2 electrons. Bonds count as 1 electron.
 - 3. Compare number of electrons in structure to NORMAL number of valence electrons.
 - Extra electrons in structure? (-) charge
 - Fewer electrons in structure? (+) charge

Formal Charge Examples



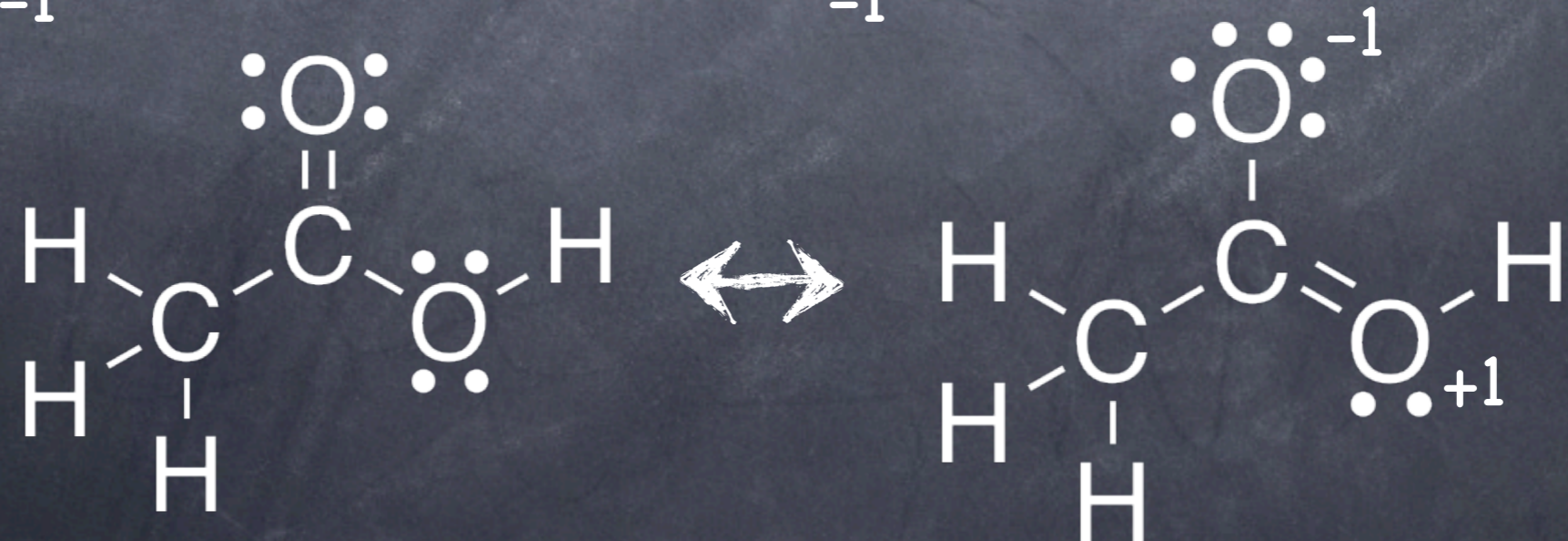
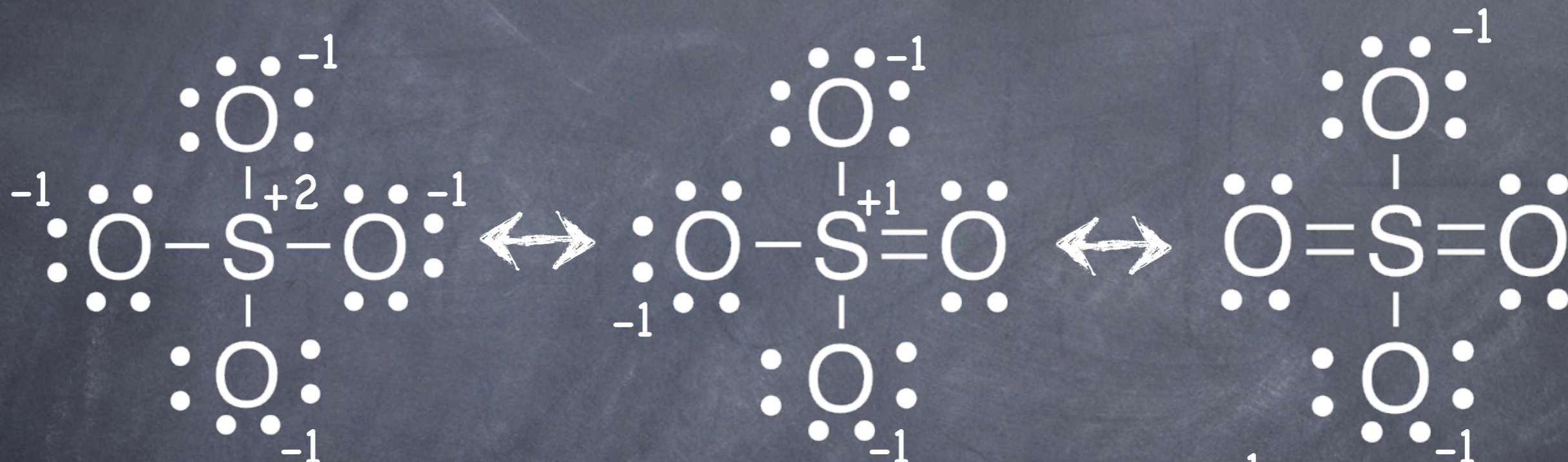
When 1 Structure Doesn't Show the Full Picture...

- Our ability to represent the true bonding nature of molecules is limited by the way our brains work and how we draw things!
- We can draw multiple structures that differ only by placement of electrons.
- What does this mean?

Rules for Drawing Resonance Structures

- 1. Move electrons ONLY, not atoms.
- 2. Don't split up electron pairs. If electrons are paired, move both together.
- 3. Follow Lewis structure general rules.
 - Note: Expanded octet or non-octets are possible.

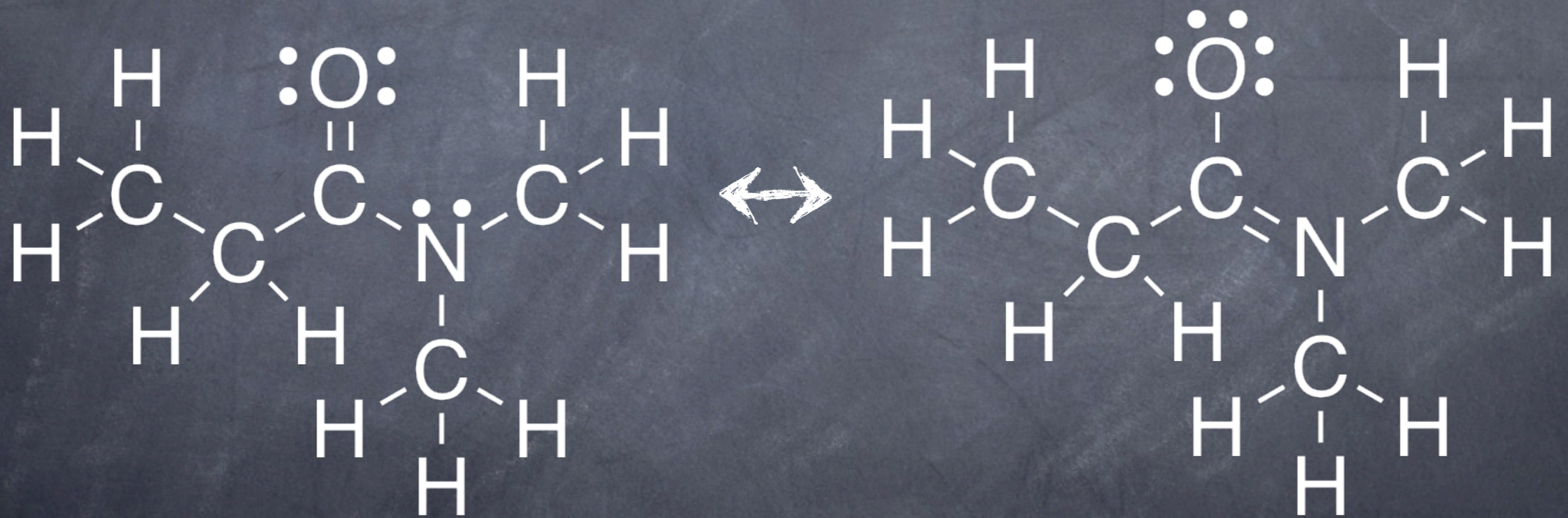
Resonance Structure Examples



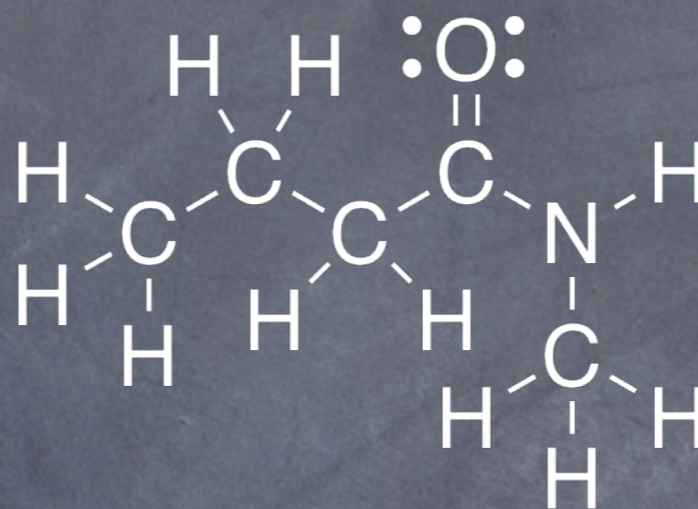
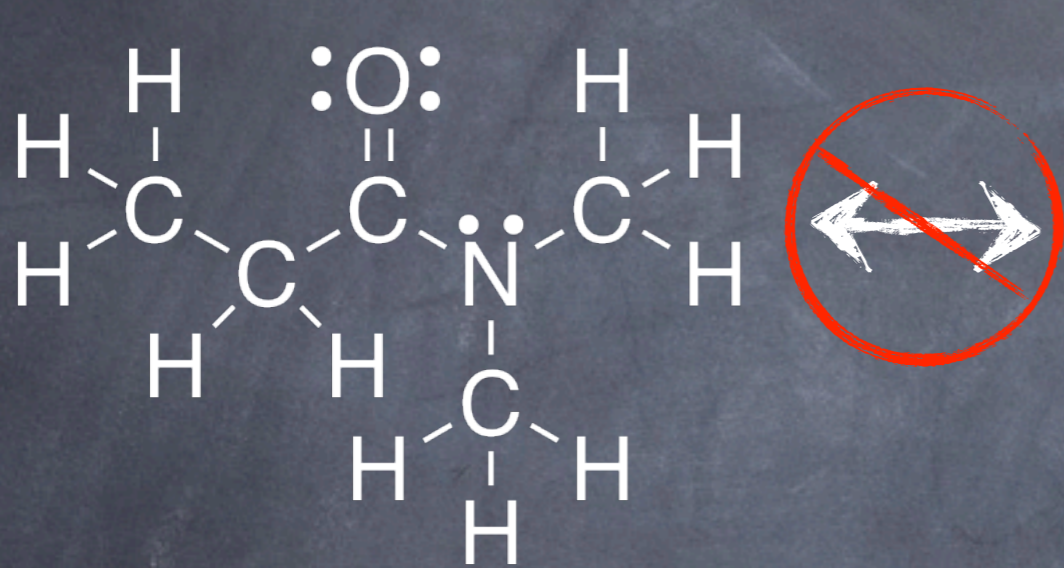
The Curved-Arrow Formalism

- Organic chemists use curved arrows to show movement of electrons.
- Rules for "arrow pushing":
 - 1. Arrows show movement of ELECTRONS ONLY!
 - 2. Arrows begin at electrons, so you have two options:
 - A. Non-bonding (lone) pairs
 - B. Existing bonds
 - 3. Arrows end where the electrons are going, so you have two options:
 - A. An atom (to form a new non-bonding pair)
 - B. An existing bond (to form a double or triple bond)
- THESE RULES ARE VERY IMPORTANT!!! YOU WILL USE THEM IN ALL OCHEM CLASSES!!!

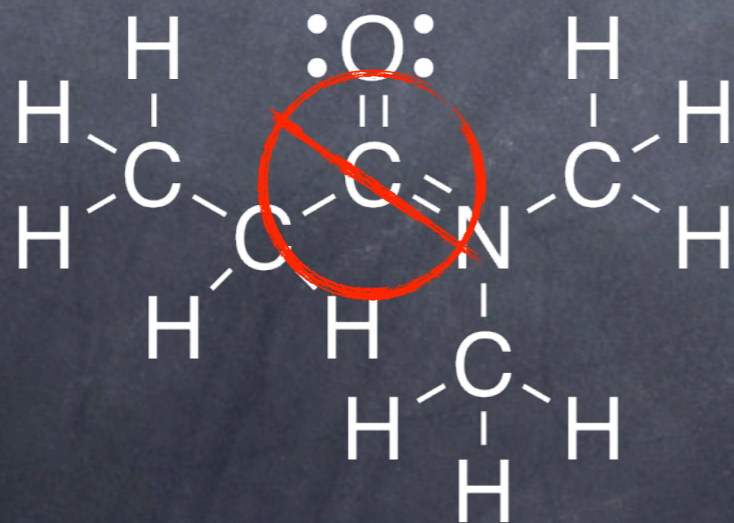
Resonance Structure and Curved Arrow Practice



NOT Resonance Structure Examples



too many
 e^- on C!!!



Resonance Theory

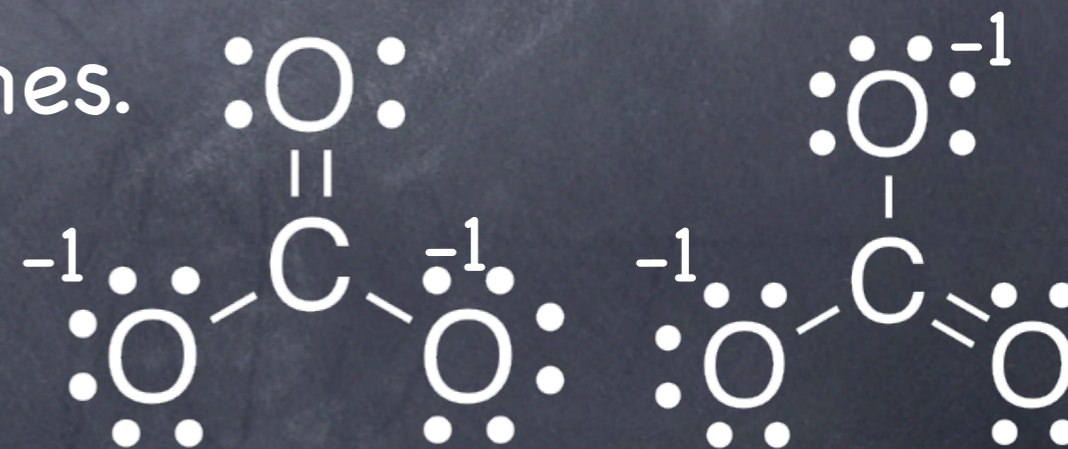
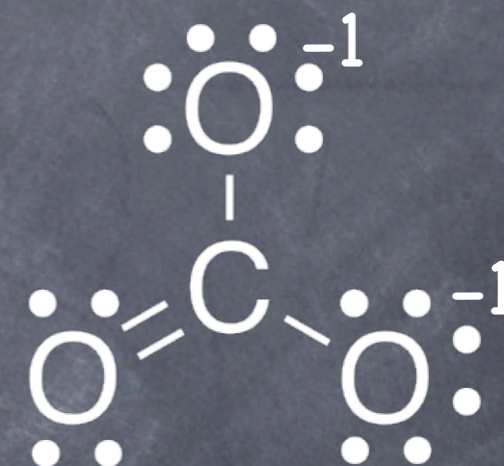
- Resonance structures are NOT REAL.
- Resonance structures are NOT IN EQUILIBRIUM. (Note the arrow type.)
- Resonance structure are NOT ISOMERS.
- So what are they?!

Resonance Hybrids

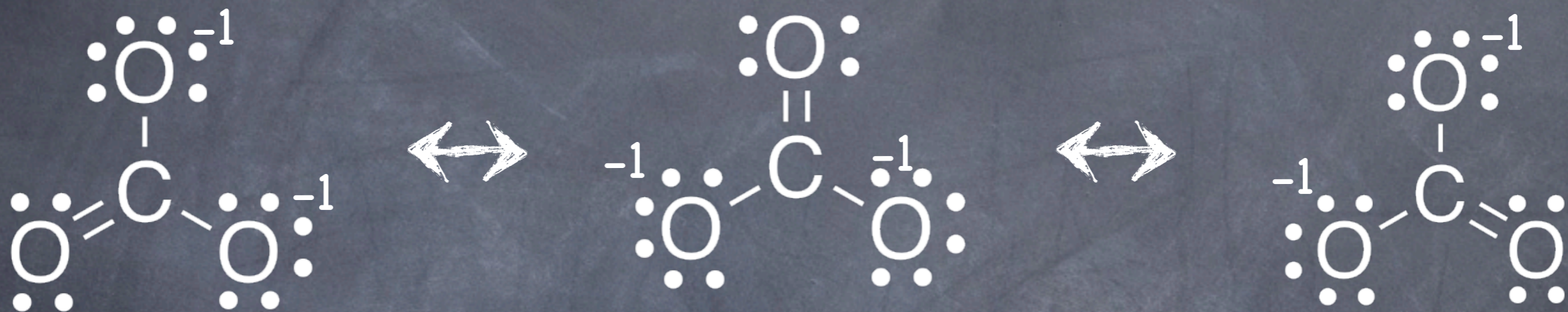
• Resonance structures we draw are the extremes of a spectrum.

• The "real" structure of the molecule is called a resonance hybrid and is somewhere between the extremes.

• How do we know that?

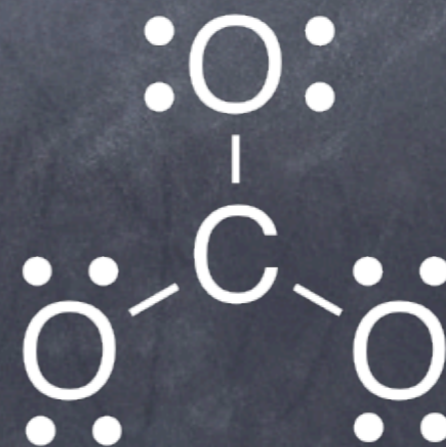


Evidence that Lewis Structures Fail

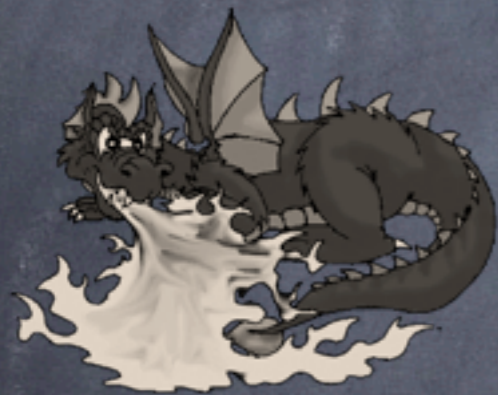


All C-O bonds equal!

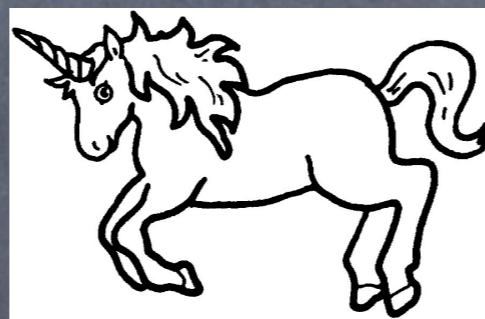
Bond	Length
C-O	143 pm
C=O	122 pm
carbonate	129 pm



More on Resonance Hybrids



+



=



Fictitious

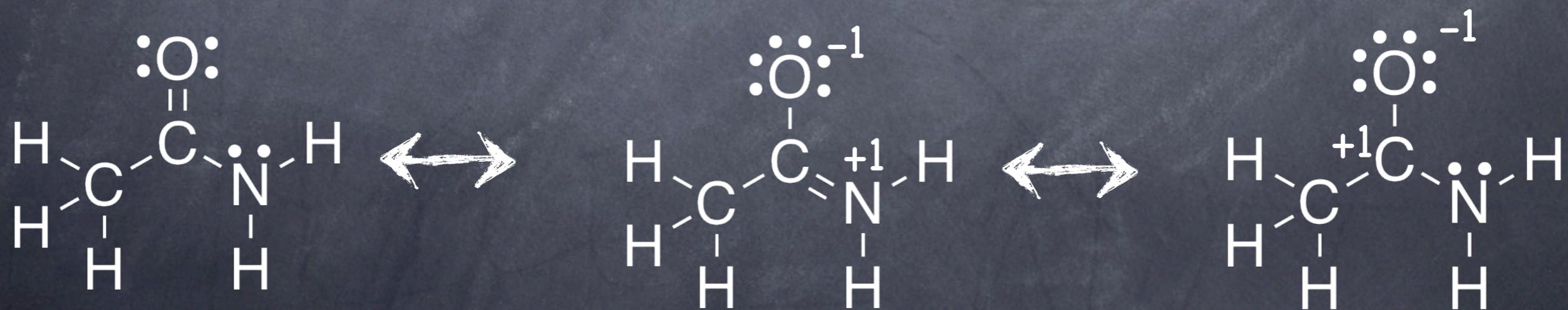
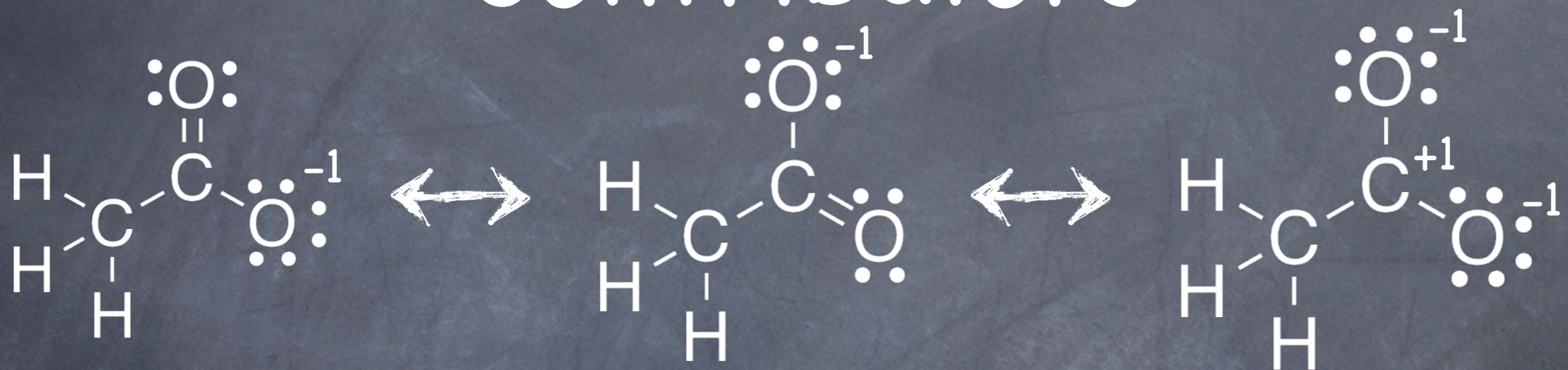
Fictitious

Real!

Not All Resonance Structures are Created Equally!

- Maximize bonds and octets.
- Minimize formal charge.
- When formal charge is necessary, (-) on more electronegative atoms, (+) on less electronegative atoms.
- Major contributors vs. minor contributors.

Major and Minor Contributors



Wrapping Up

- Practice drawing Lewis structures, including formal charge.
- Practice drawing resonance structures, including formal charge.
- Practice using the curved arrow notation.
- Practice determining whether a resonance structure would be a major or minor contributor to the resonance hybrid.
- Practice drawing the resonance hybrid.