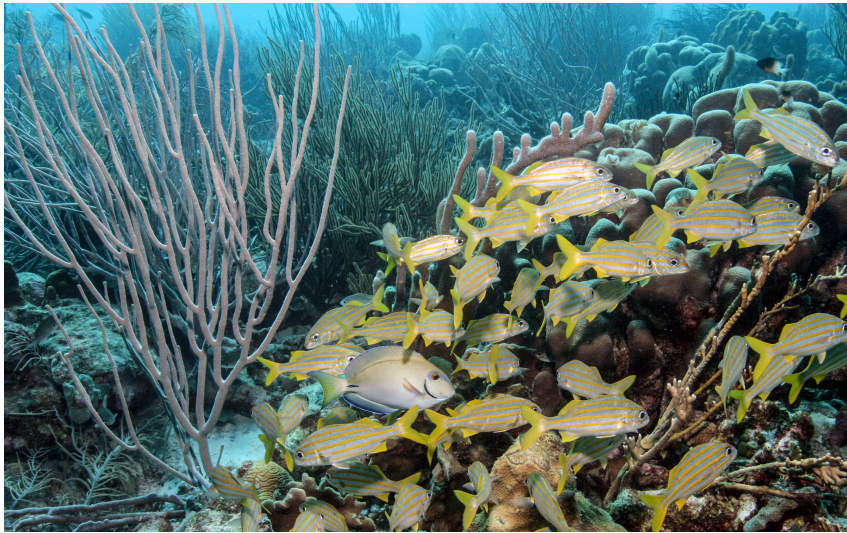
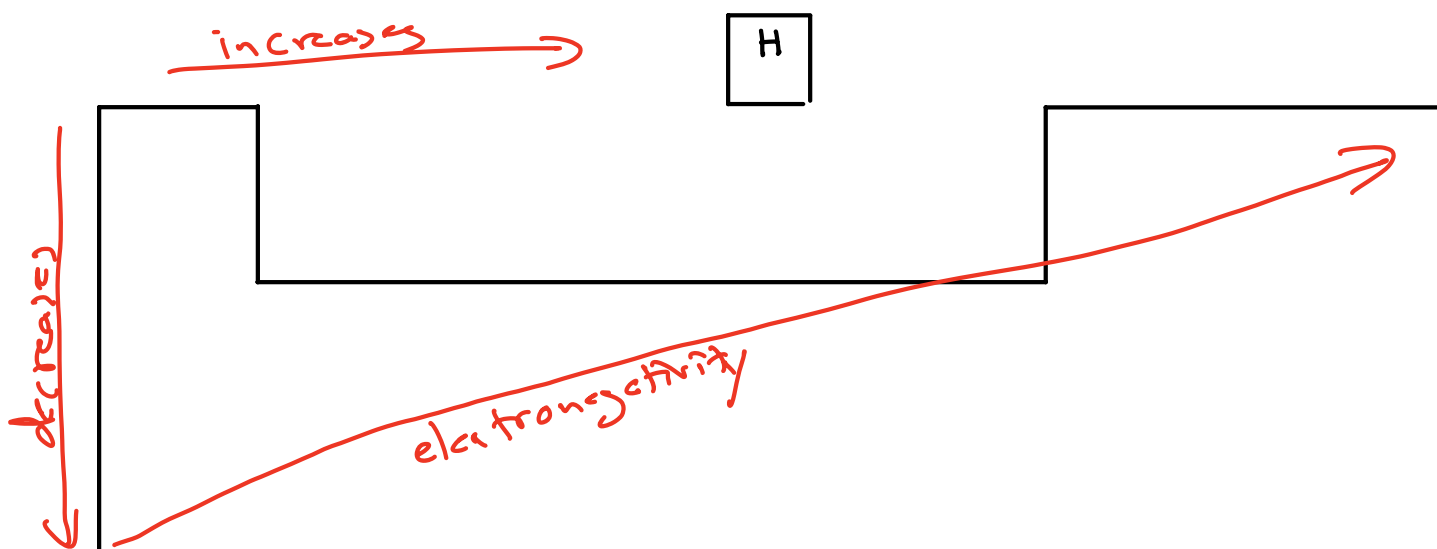




Formal Charge $\rightarrow$ not a theory $\rightarrow$ it just keeps track of electrons vs. protons in a molecule

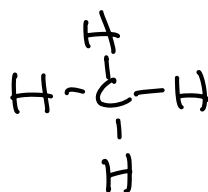
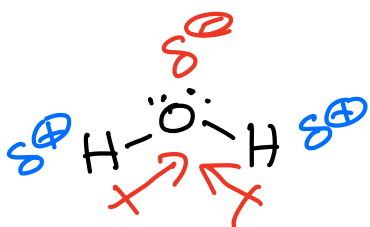
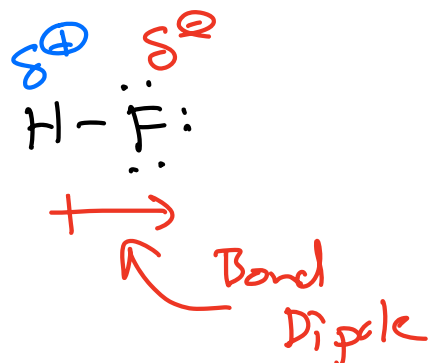
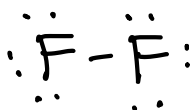
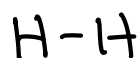
Theory $\rightarrow$ tells us quantitatively where electrons are located

$\hookrightarrow$ Linus Pauling $\rightarrow$ more electron density is around the more electronegative atom



Periodic Table

Electronegativity $\rightarrow$ increases with increasing nuclear charge
 $\rightarrow$ decreases with increasing number of electrons
 $\Rightarrow$ "Based on electrostatic attraction between proton in the nucleus and electrons"



b.p. 100°C

$\nearrow$
 Because of partial charges, molecules attracted to each other
 ~~~~~  
 Stick together

b.p.  $-161^\circ\text{C}$

$\nearrow$   
 Minimal attraction between molecules



**Organic Chemistry is the study of carbon-containing molecules.**

**This class has two points.**

***The first point of the class is to understand the organic chemistry of living systems. We will teach you how to think about and understand the most amazing things on the planet!!***

Water is essential for life, you will learn why water has such special properties. 8/24/26

You will learn the secret structural reason proteins, the most important molecular machines in our bodies, can support the chemistry of life.

You will learn why when you take Advil for pain, exactly half of what you take works, and the other half does nothing.

You will learn how toothpaste works.

You will learn how a single chlorofluorocarbon refrigerant molecule released into the atmosphere can destroy many, many ozone molecules, leading to an enlargement of the ozone hole.

You will learn how medicines like Benadryl, Seldane, and Lipitor work.

You will learn how Naloxone is an antidote for an opioid overdose.

You will learn why Magic Johnson is still alive, decades after contracting HIV.

You will learn how MRI scans work.

***The second point of organic chemistry is the synthesis of complex molecules from simpler ones by making and breaking specific bonds.***

You will learn how to understand movies of reaction mechanisms like alkene hydration.

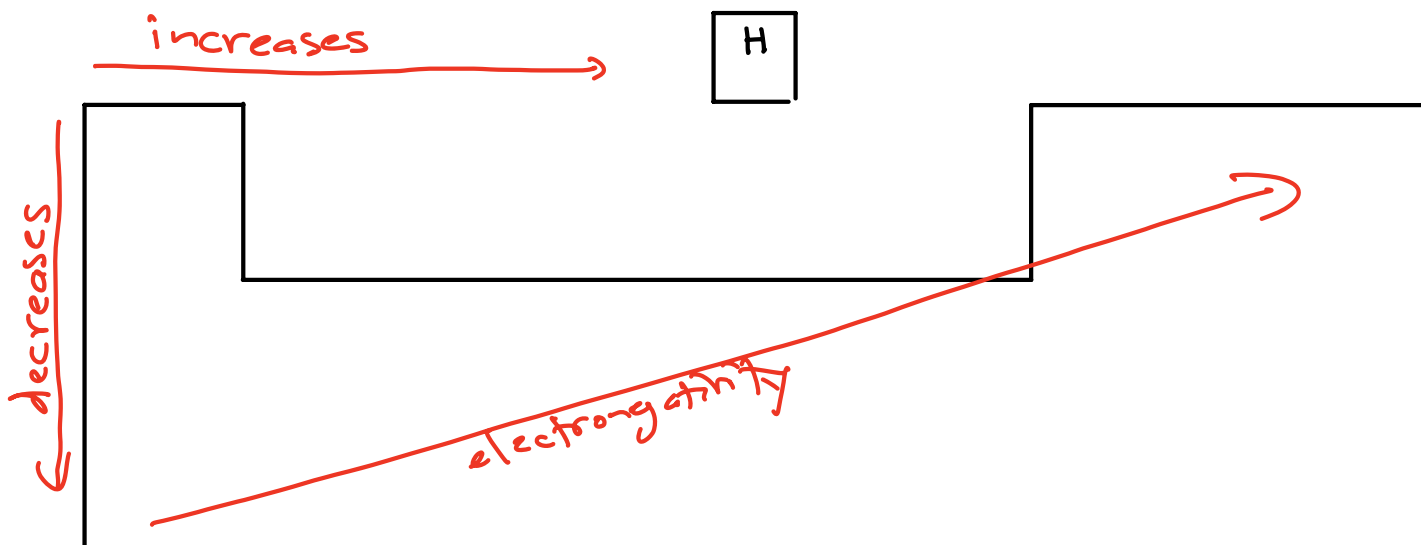
You will learn reactions that once begun, will continue reacting such that each product molecule created starts a new reaction until all the starting material is used up.

You will learn reactions that can make antifreeze from vodka.

You will learn a reaction that can make nail polish remover from rubbing alcohol.

You will learn how to look at a molecule and accurately predict which atoms will react to make new bonds, and which bonds will break during reactions.

You will learn how to analyze a complex molecule's structure so that you can predict ways to make it via multiple reactions starting with less complex starting molecules.



| 1A        |           | 2A        |           |           |           |           |           |           |           |           |           |           |           | 3A        | 4A        | 5A        | 6A       | 7A       |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|
| Li<br>1.0 | Be<br>1.5 |           |           |           |           |           |           |           |           |           |           |           |           | B<br>2.0  | C<br>2.5  | N<br>3.0  | O<br>3.5 | F<br>4.0 |
| Na<br>0.9 | Mg<br>1.2 | 3B        | 4B        | 5B        | 6B        | 7B        | 8B        |           |           | 1B        | 2B        | Al<br>1.5 | Si<br>1.8 | P<br>2.1  | S<br>2.5  | Cl<br>3.0 |          |          |
| K<br>0.8  | Ca<br>1.0 | Sc<br>1.3 | Ti<br>1.5 | V<br>1.6  | Cr<br>1.6 | Mn<br>1.5 | Fe<br>1.8 | Co<br>1.8 | Ni<br>1.8 | Cu<br>1.9 | Zn<br>1.6 | Ga<br>1.6 | Ge<br>1.8 | As<br>2.0 | Se<br>2.4 | Br<br>2.8 |          |          |
| Rb<br>0.8 | Sr<br>1.0 | Y<br>1.2  | Zr<br>1.4 | Nb<br>1.6 | Mo<br>1.8 | Tc<br>1.9 | Ru<br>2.2 | Rh<br>2.2 | Pd<br>2.2 | Ag<br>1.9 | Cd<br>1.7 | In<br>1.7 | Sn<br>1.8 | Sb<br>1.9 | Te<br>2.1 | I<br>2.5  |          |          |
| Cs<br>0.7 | Ba<br>0.9 | La<br>1.1 | Hf<br>1.3 | Ta<br>1.5 | W<br>1.7  | Re<br>1.9 | Os<br>2.2 | Ir<br>2.2 | Pt<br>2.2 | Au<br>2.4 | Hg<br>1.9 | Tl<br>1.8 | Pb<br>1.8 | Bi<br>1.9 | Po<br>2.0 | At<br>2.2 |          |          |

|           |           |           |
|-----------|-----------|-----------|
| <1.0      | 1.5 – 1.9 | 2.5 – 2.9 |
| 1.0 – 1.4 | 2.0 – 2.4 | 3.0 – 4.0 |



## Formal Charge



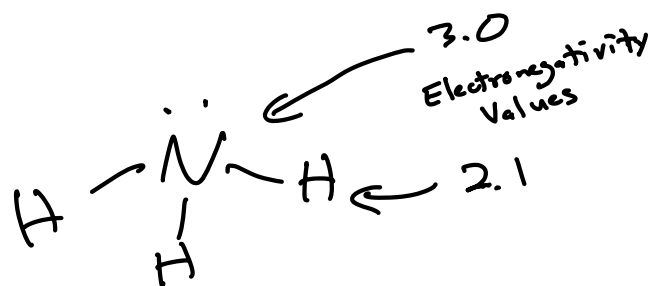
Method of counting  
# of protons vs.  
# of electrons



Identifies molecules  
and atoms with  
full charges  
# protons  $\neq$  # electrons



NOT a theory  
does not REALLY  
always tell you  
where electrons  
are in molecules



## Polar Covalent Bonds



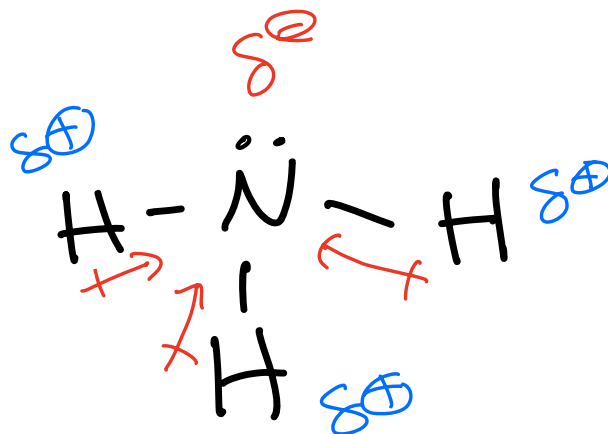
Understanding  
properties of  
molecules



Identifies partial  
charges  
associated with  
bonds



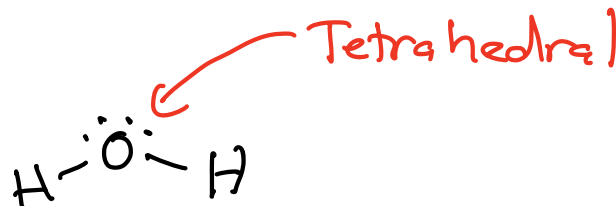
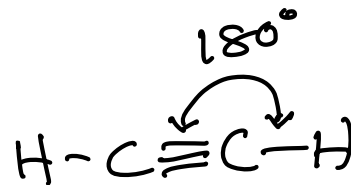
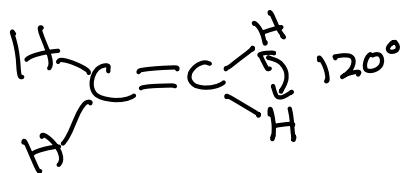
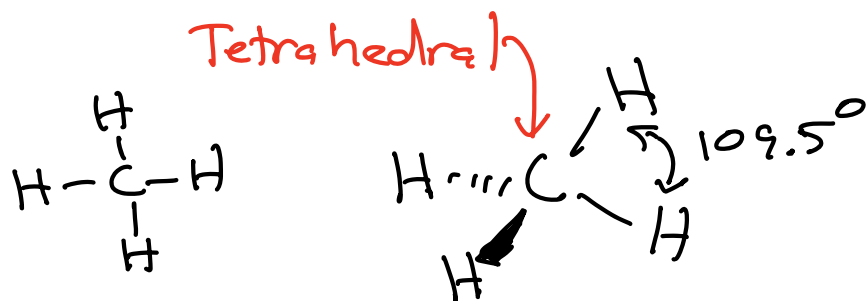
Based on  
a theory  $\rightarrow$   
very accurate



# Shapes $\rightarrow$ VSEPR

$\hookrightarrow$  1<sup>st</sup> approximation  $\rightarrow$  areas of electron density

(bonds or lone pairs)  
repel each other and  
stay as far apart as possible  
around an atom

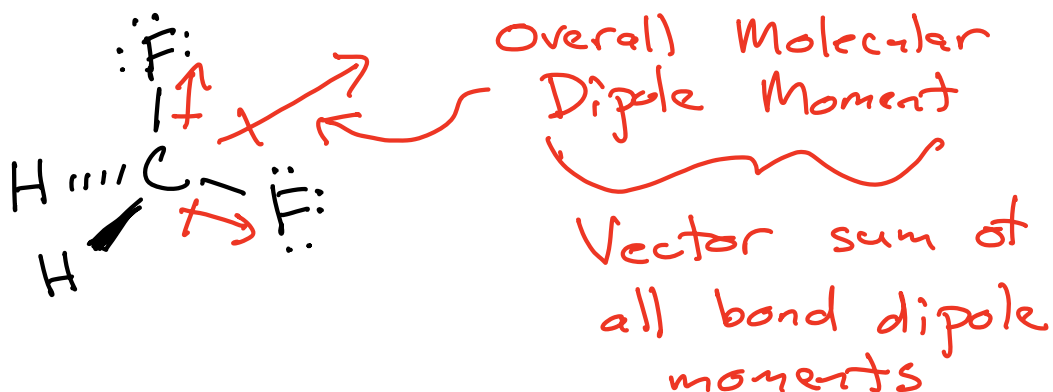
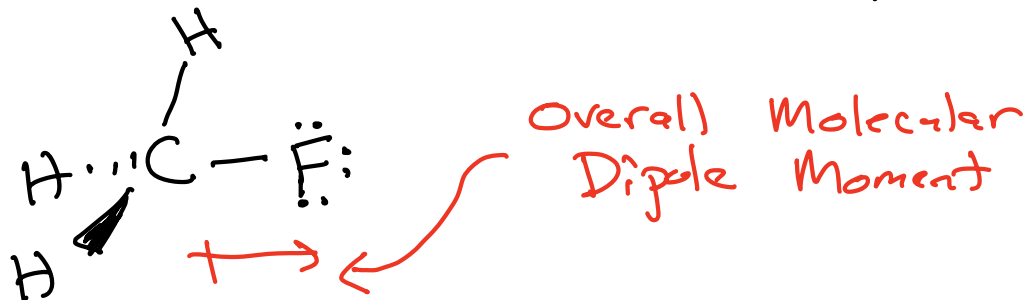


VSEPR  $\Rightarrow$  Model  $\Rightarrow$  helpful

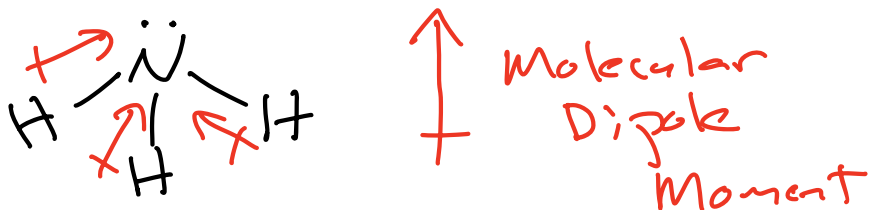
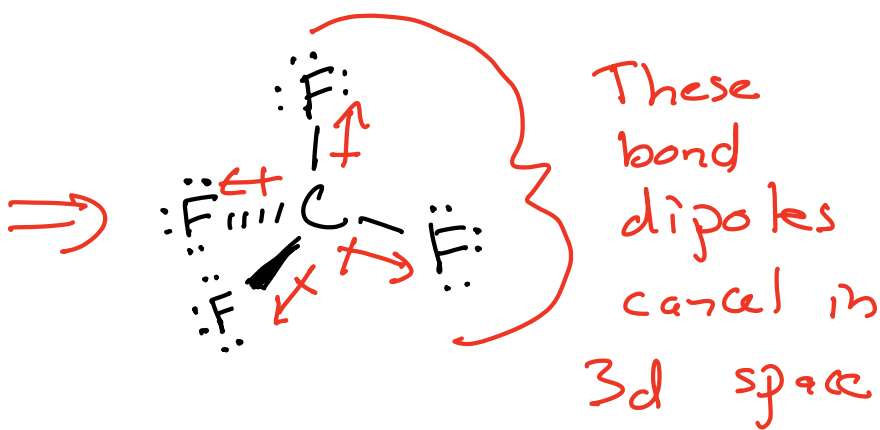
BUT it's sometimes  
**WRONG!**



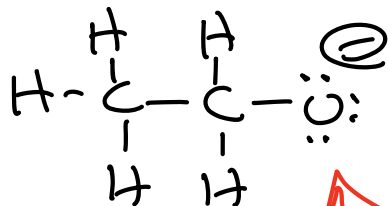
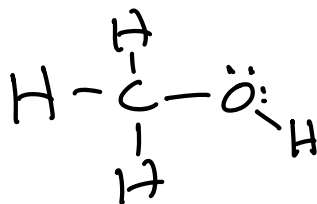
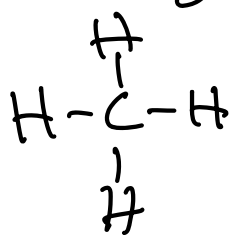
Putting it all together: Molecular Dipoles



No Overall Molecular Dipole Moment



The good news: Lewis structures accurately describe molecules (most of the time)

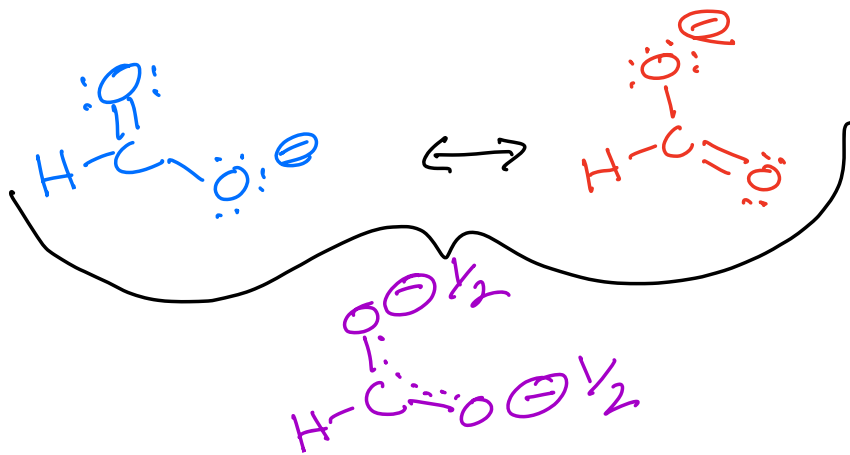


$\ominus$  charge is indeed on O atom

However,

Contributing Structures  $\Rightarrow$  cases in which no single Lewis structure describes the true situation (bonding/charges)

$\Rightarrow$  Combined to make hybrid structure  $\Rightarrow$  NOT equilibrating back and forth  $\Rightarrow$  The hybrid describes a SINGLE structure



## Contributing Structures $\Rightarrow$ Generally

interconvert double (tr) bonds and lone pairs on adjacent atoms (sometimes  $\oplus$  charges or unpaired electrons)

$\Rightarrow$  Must be reasonable Lewis structures

$\rightarrow$  NEVER move atoms  $\rightarrow$  only electrons (lone pairs, bonds) are different

$\rightarrow$  NEVER exceed filled valence shells

$\rightarrow$  NEVER create unpaired electrons that did not previously exist

$\rightarrow$  when deciding which contributing structure is the major contribution rank according to the following

Priority  $\uparrow$

$\rightarrow$  1) More atoms with filled valence shells

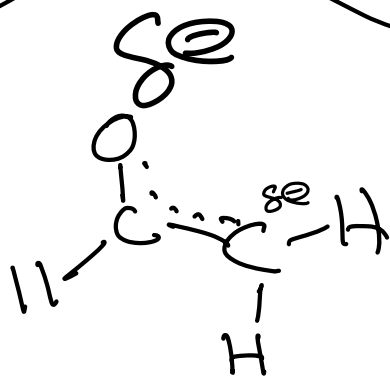
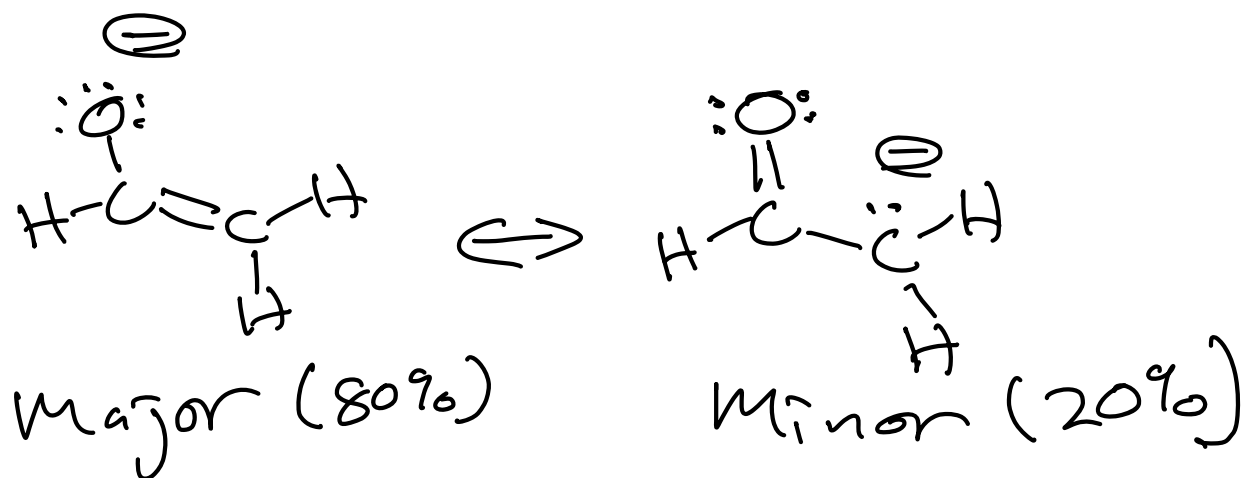
$\rightarrow$  2) More total number of covalent bonds

$\rightarrow$  3) Fewer overall formal charges

$\rightarrow$  4)  $\ominus$  on the more electronegative element and vice versa



# Classic Example



Office Hours Today: 4-5 PM BUR 106

Review Session Tonight: 7-9 PM WEL 2.224  
(Gen Chem Review)

Next Monday → No class! (Labor Day)

Next Wednesday → Flipped Class!  
(September 3)

Check out the  
ROTD for Sept. 3  
or the Canvas Calendar  
for a link

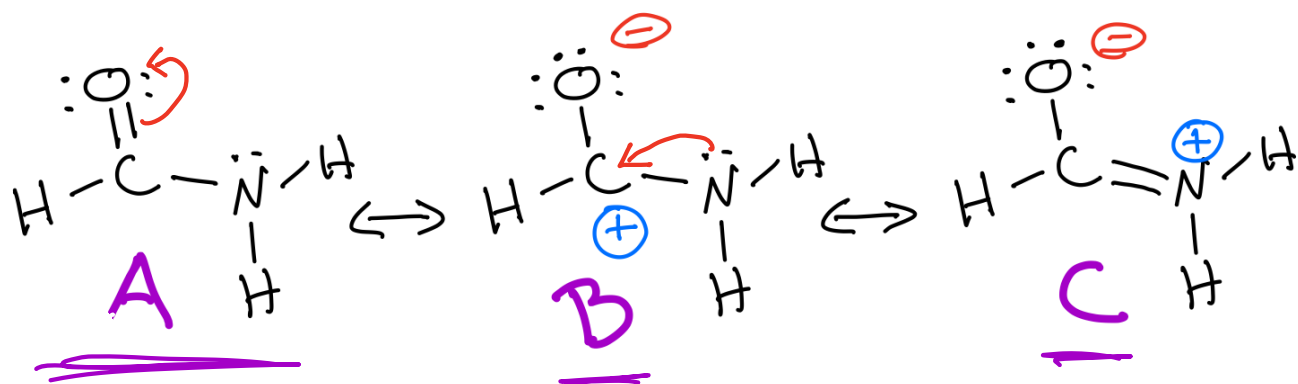
Watch a recording  
of my 3<sup>rd</sup> lecture  
from last year before  
class

T.A.'s will  
be there to  
help you!

Everyone can  
get 100%  
correct!!

→ Come to class at  
the normal time and  
place to work on  
your Homework 1  
due that evening

The curious case of amide  
contributing structures: All  
three are important



Why are B and C  
worth considering?



Time  
Capsule

1) Golden Rules of Chemistry  
# 5 and # 7

Quantum Mechanics  
Baby!!

Electrons are so incredibly small that they have some properties of particles and some properties of waves

\*\*\*\* For organic chemistry we focus only on the wave properties of electrons!!!

Electrons are three-dimensional waves!!

