Chapter 7 Part 3

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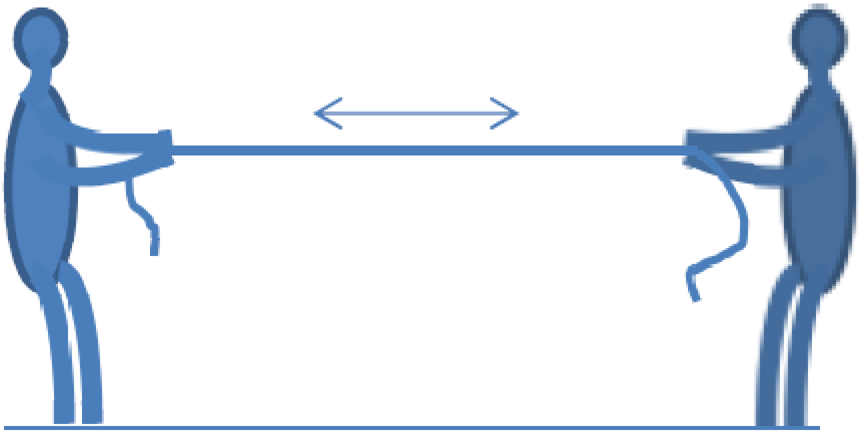
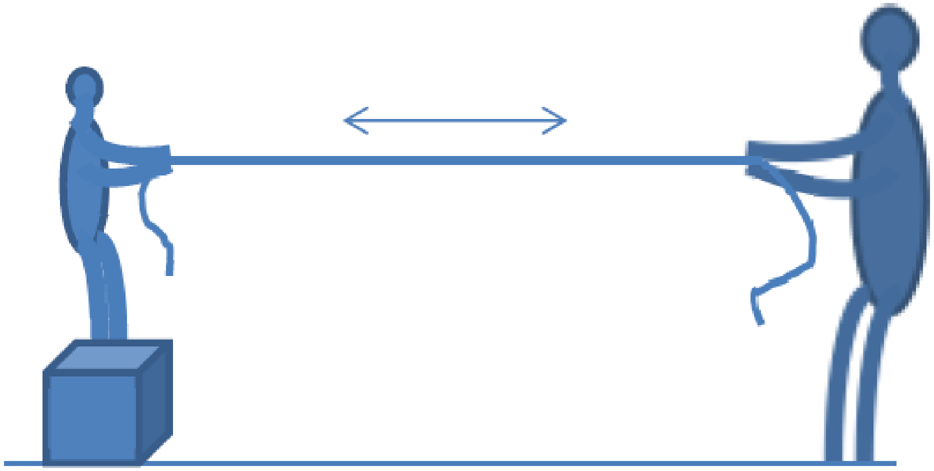
Tug of war

- Imagine a tug of war game played by two people of equal strength. If they pull against each other neither will win the game because neither has an advantage.
- Equal and opposite force is being asserted and there is no net gain.



Tug of war

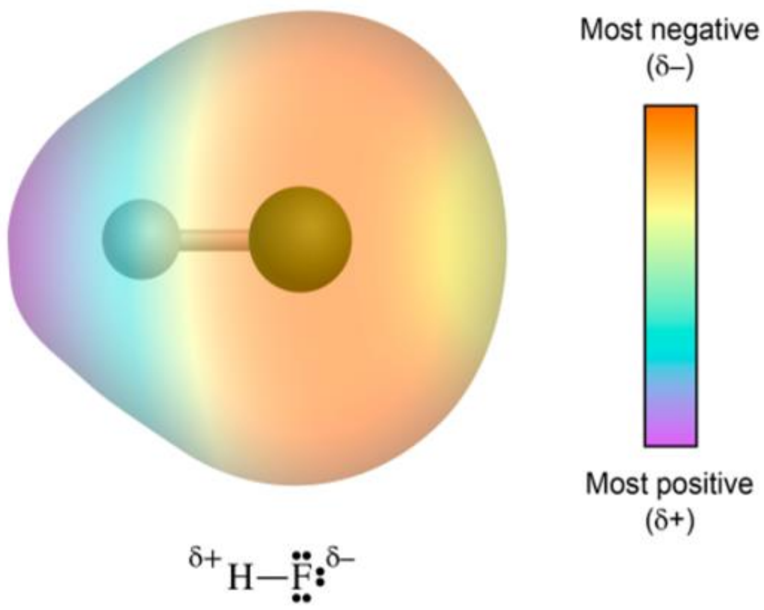
- Now, imagine two people of unequal strength play the game.
- Which will win?
- Why did you choose this one?



Bond polarity

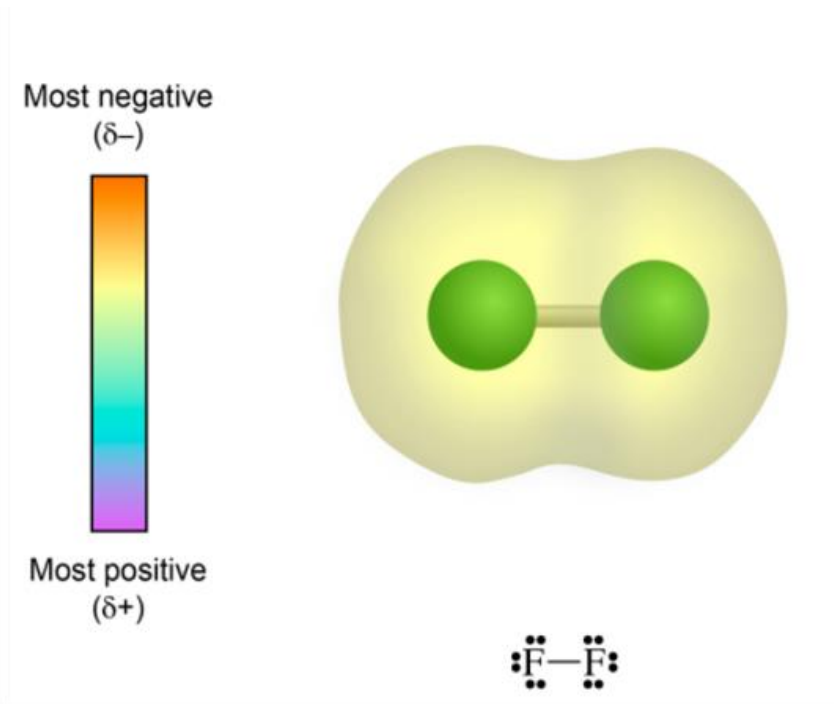
- Electronegativity is the ability of an atom to attract electrons to itself within a bond.
- We can think about the atoms on either side of a bond as pulling on the electrons located in the bond.
- The strength of an atom's pull on the electrons in the bond is determined by its electronegativity.
- This ultimately results in the electron density in the bond being pulled towards one of atoms in the bond.

Polar Bonds



- Two different atoms generally share electrons unevenly because they have different electronegativities
- This causes electron density in the electron cloud to shift to one side of the bond
- This type of uneven sharing of electrons is called polar covalent bonding

Nonpolar bonds

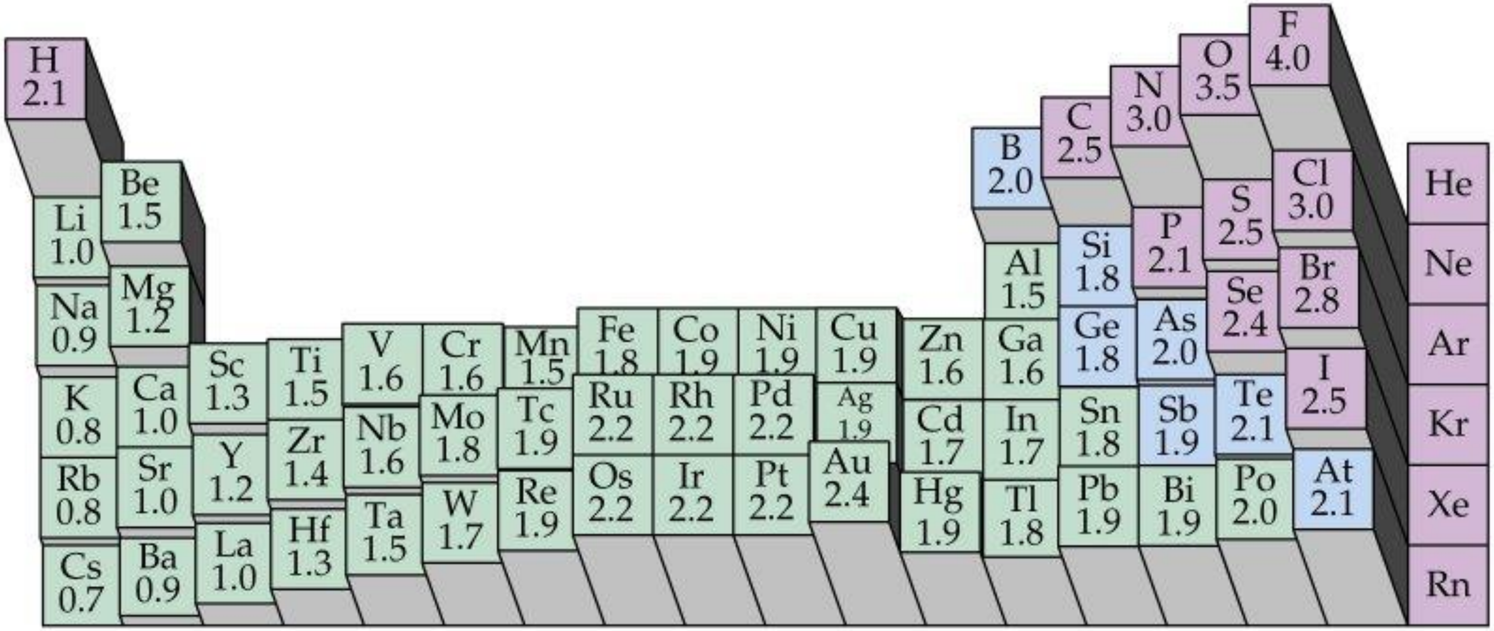


- Two identical atoms generally share electrons evenly because they have identical electronegativities
- This causes electron density in the electron cloud to be spread evenly across the bond
- This type of even sharing of electrons is called nonpolar covalent bonding

Comparison of Bonding in HF and F_2

- The difference in charge density results in a partial negative charge, δ^-, on the F atom and a partial positive charge, δ^+, on the H atom.
- These positive and negative poles in HF indicate a charge separation and creates a polar bond.
- The completely evenly shared bonding electrons in F_2 creates a nonpolar bond.

Electronegativity



Differences in Electronegativity

- Larger differences in electronegativity between bonded atoms lead to larger bond polarities
- The only truly nonpolar bond exists when the two atoms have exactly the same electronegativity.
- However, electronegativity difference between carbon and hydrogen is so small that C-H bonds are generally considered nonpolar

$$C - F > C - Cl > C - Br > C - H$$

Most Polar   Less Polar   Nonpolar

Bond Polarity

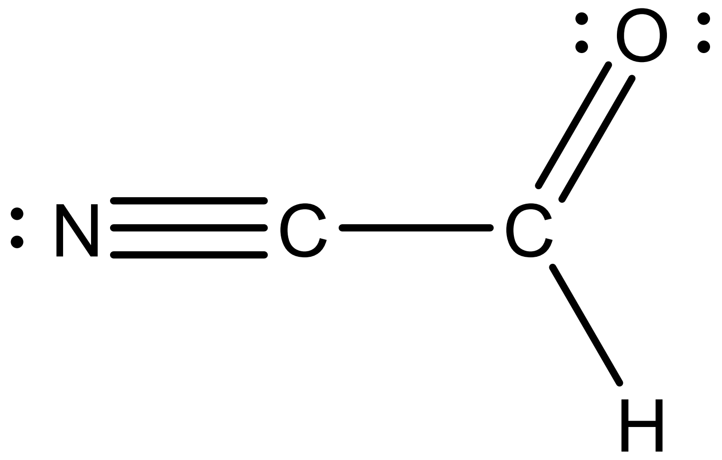
Which bond is the most polar?

A. C–H
B. C–N
C. C–O
D. C–F

Bond Order

- Bond order is the number of bonding lines between two bonded atoms

- CN bond order is 3
- CC bond order is 1
- CH bond order is 1
- CO bond order is 2



Bond Order & Bond Length

- Bond length increases with increasing atomic radius

$$\text{Shortest} \quad C-F < C-Cl < C-Br \quad \text{Longest}$$

- Bond length increases with decreasing bond order

$$\text{Shortest} \quad C \equiv N < C = N < C-N \quad \text{Longest}$$

Bond Energy (Bond Enthalpy)

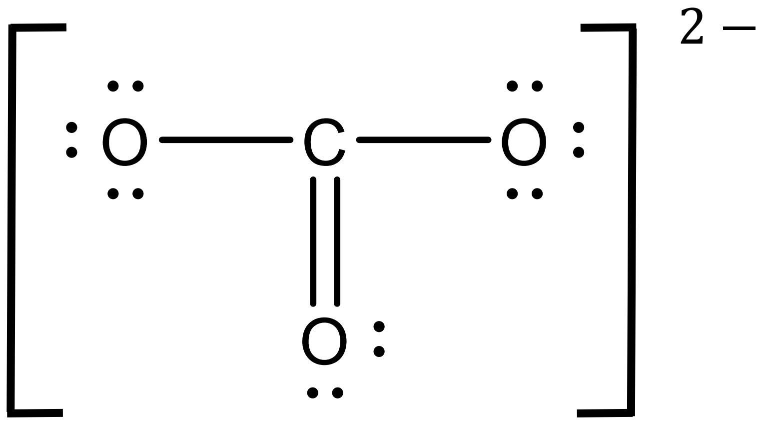
- Bond energy is the energy required to break a bond
- Bond strength increases with increasing bond energy
- Bond strength increases with increasing bond order

Strongest		Weakest
Highest bond energy	$C \equiv N > C = N > C - N$	Lowest bond energy
Shortest		Longest

Calculating Bond Order of a Resonance Structure

$CO_3{}^{2-}$

$$\text{bonding order of CO} = \left(\frac{\text{number of CO bonding lines}}{\text{number of CO bonding locations}}\right) = \frac{4}{3}$$



Bond order

Calculate the bond order of the chlorine-oxygen bond in perchlorate. Oxygen is more electronegative than chlorine.

Bond energy

Would it require more energy to break the carbon-oxygen bond in CO_2 or CO_3^{2-}?

Enthalpy & Average Bond Energy

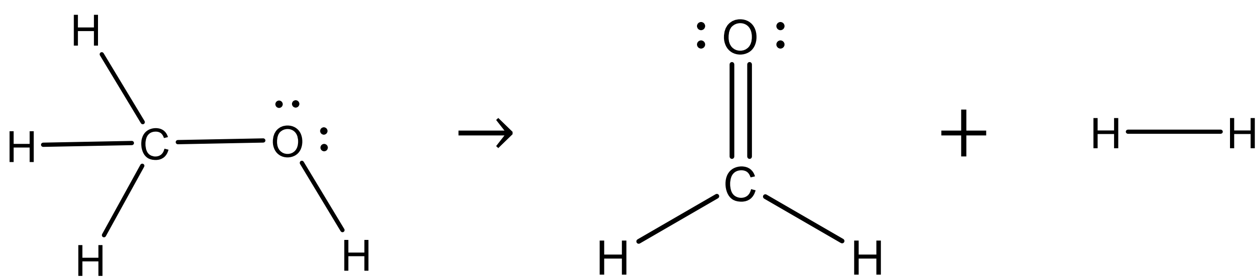
- Average bond energy values can be used to calculate the enthalpy of reaction for gas phase reactions

$$\Delta H^\circ = \sum(\text{Energies of bonds broken}) - \sum(\text{Energies of bonds formed})$$

Enthalpy of Reaction from Bond Enthalpies

Find the enthalpy of reaction for the reaction below (C – H is 411 kJ/mol, C – O is 350 kJ/mol, O – H is 464 kJ/mol, H – H is 436 kJ/mol, and C = O is 741 kJ/mol).

$$CH_3OH(l) \rightarrow CH_2O(g) + H_2(g)$$



Enthalpy of Reaction from Bond Enthalpies

Use bond enthalpies to calculate the ΔH_{rxn} (in kJ/mol) for the reaction below.

$$N_2(g) + 3\,F_2(g) \rightarrow 2\,NF_3(g)$$

Bond	ΔH (kJ/mol)
N–N	240
N=N	418
N≡N	941
F–F	157
N-F	270