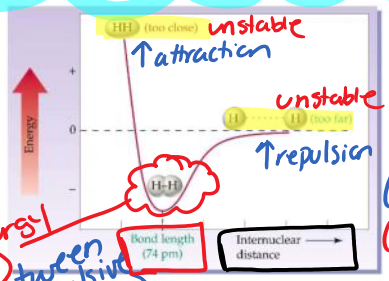
Lesson #5: Bond Energy & Resonance

May 23, 2018 4:30 PM

E. BOND ENERGY; RELATIVE BOND STRENGTH & REACTIVITY



Potential Energy.

⇒ To break a bond the E_p (stored in the bond) must be INCREASED

∴ bond breaking REQUIRES energy input

⇒ E_p converted into E_k (kinetic energy) as bond forms

∴ bond formation results in energy output

(break) If energy input > energy output, then reaction is ENDOthermic

(form) If energy input < energy output, then reaction is EXOthermic

Energy

Low energy (stable) (balance between attractive & repulsive forces)

Bond Energy = the energy (kJ/mol) required to separate two bonded atoms (break a bond)

Example One mole of $H_2(g)$ requires 436 kJ of energy input to separate the two H atoms.
Conversely, when two H atoms form a bond, $\frac{436\ kJ}{mol} \times 2\ mol = 872\ kJ$ energy released

The bond energies have been determined for every kind of covalent bonds. We can look them up!

Significance: Allows chemists to predict ΔH for a given chemical reaction, which is done as follows:

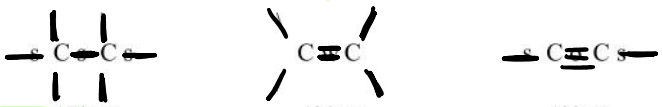
Δ change in Enthalpy

ΔH = Sum of the bond energies of broken bonds – Sum of the bond energies of bonds formed

Bond Characteristics

	Single Bonds	Double Bonds	Triple Bonds
Length	longest		shortest
Strength	weakest		strongest
Reactivity	most reactive (easiest to break + re form)		least reactive

Examples



	C–C	C=C	C≡C
Bond Length:	154 pm	134 pm	120 pm
Bond Energy:	348 kJ/mol	614 kJ/mol	839 kJ/mol

? energy required to break the bond.

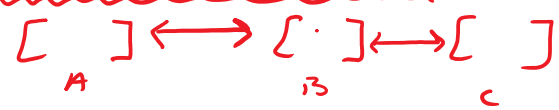
F. RESONANCE

In many cases, the Lewis structure of a molecule predicts more than one possible placement for double bonds. **When more than one possible arrangement exists, we must draw all the resonance structures.** In fact, the experimental data indicates that the actual molecule is a "blending" of all the possible resonance structures. ***Resonance structures*** = Lewis structures with the same arrangement of atoms, but different arrangements of electrons.

the double is in a different place

O Always use square brackets (even when there is no charge) and arrows between all of your resonance structures.

like for ions



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Example Draw the Lewis structure for the carbonate ion.

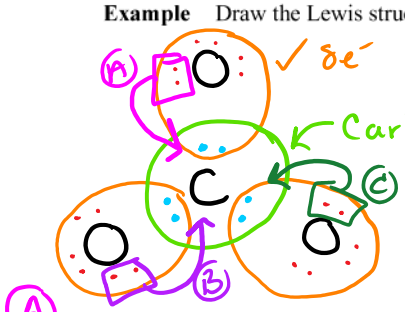
CO_3^{-2}

valence e⁻: C 3×O e⁻
4 + 3·(6) + 2 = 24e⁻

24 − 6 = 18e⁻

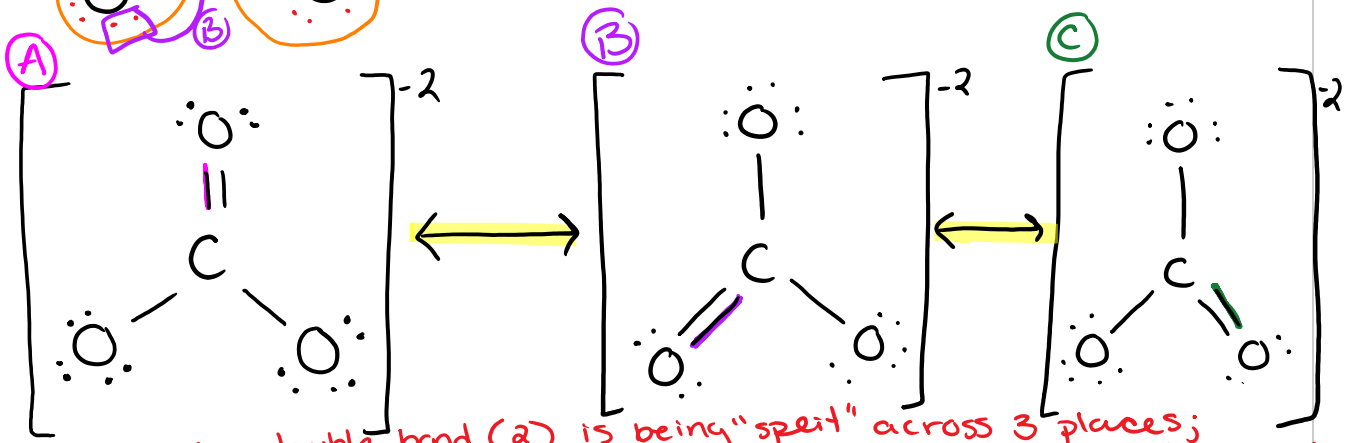
✓ 8e⁻

Carbon needs 2 more e⁻



* The double bond could be formed by ANY of the oxygens. (1 at a time... not all)

* The result is a BLEND of the resonance structures.



* The double bond (2) is being "split" across 3 places; this means each bond is really more like 1 1/3 instead of "single" or "double".

Example Which should have the shorter sulfur-oxygen bonds, SO_3 or SO_3^{2-}?

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Homework **Assignment #5** *can be completed in the space provided below*

Chemical Bonding: Exercise Set 1

1. Define the following terms:

   a) Electronegativity –

   b) Open shell –

   c) Covalent bond –

   e) Valence electrons –

   g) Valence –

   h) Ionic bond –

   i) Polar covalent bond –

2. Draw the Lewis Structure for each of the following ionic compounds (see notes for guidance):

   a) K_2S b) AlN c) Rb_3P

3. Draw the Lewis Structure for each of the given compounds (show your work):

   a) H_2Se b) Br_2 c) BeF_2

   d) NO^- e) N_2H_4 f) 1-Pentene (C_5H_{10})

4. Which atom is bigger: Pb or Si? Why?

5. Is it easier to break the double bond in O_2 or S_2? Why?

6. Explain how an ion is formed.

7. Which ionic solid should have the higher melting temperature: AlN (s) or NaF (s)? Why?

8. What number of covalent bonds is each of the following atoms expected to form?

   a) I ___ b) N ___ c) Se ___ d) B ___ e) P ___ f) C ___ g) O ___

9. What is the maximum number of covalent bonds each of the following atoms can form?

   a) N ___ b) O ___ Because each can donate a _____ _____ to _____.
   This is known as a _____ - _____ bond.

10. Draw the Lewis structures for the circular molecule benzene, C_6H_6. Explain the significance of having more than one electron dot structure. What is the name for this phenomenon? Would you expect the molecule to have different carbon-carbon bond lengths? Explain.

11. Define the "octet rule" and account for any exceptions to it.

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