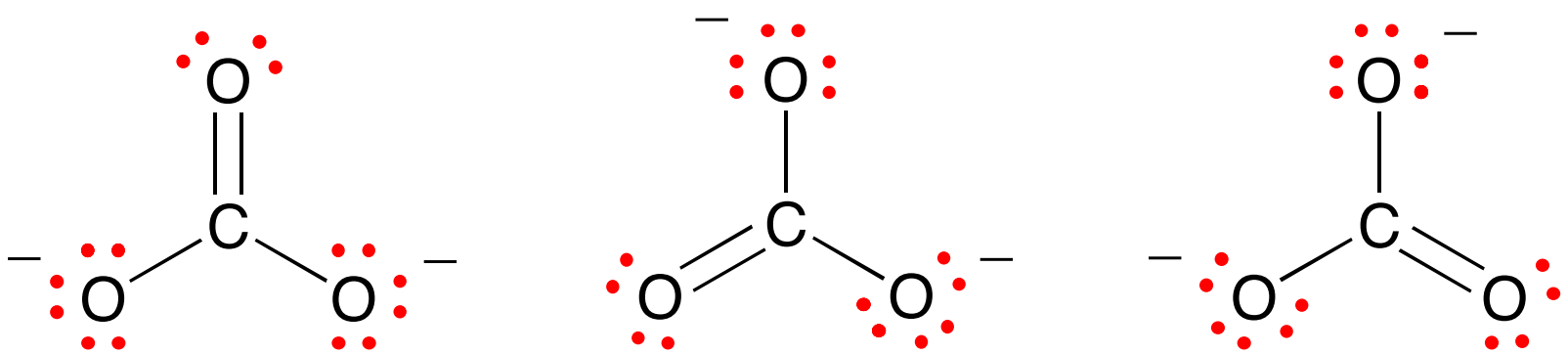
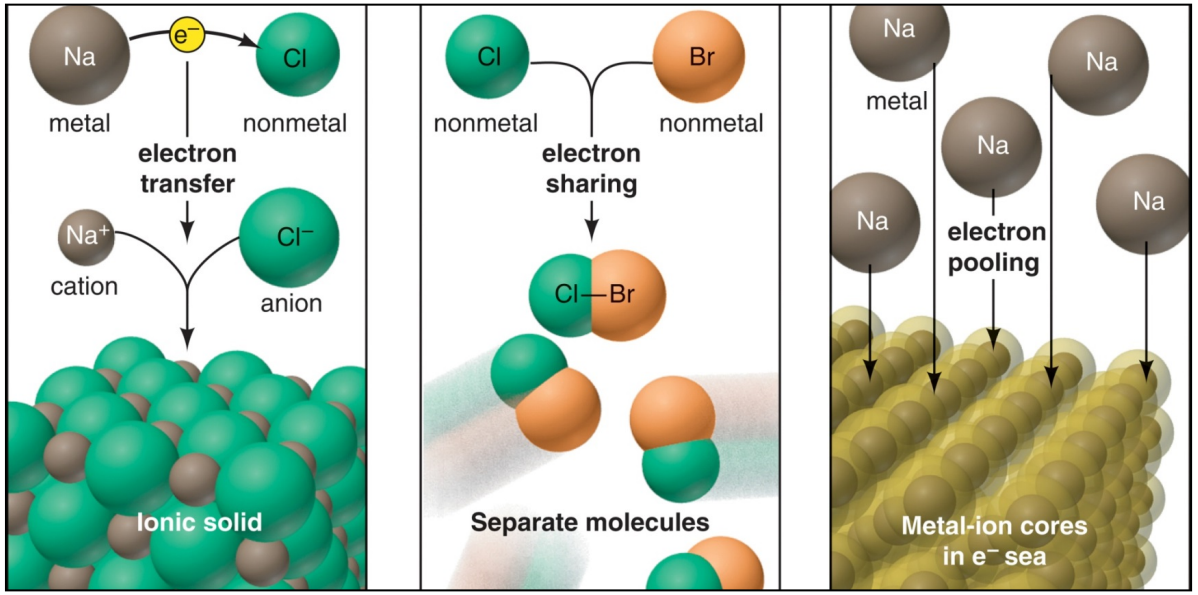
Section 8.6:
Lewis Structures



The 3 types of bonds

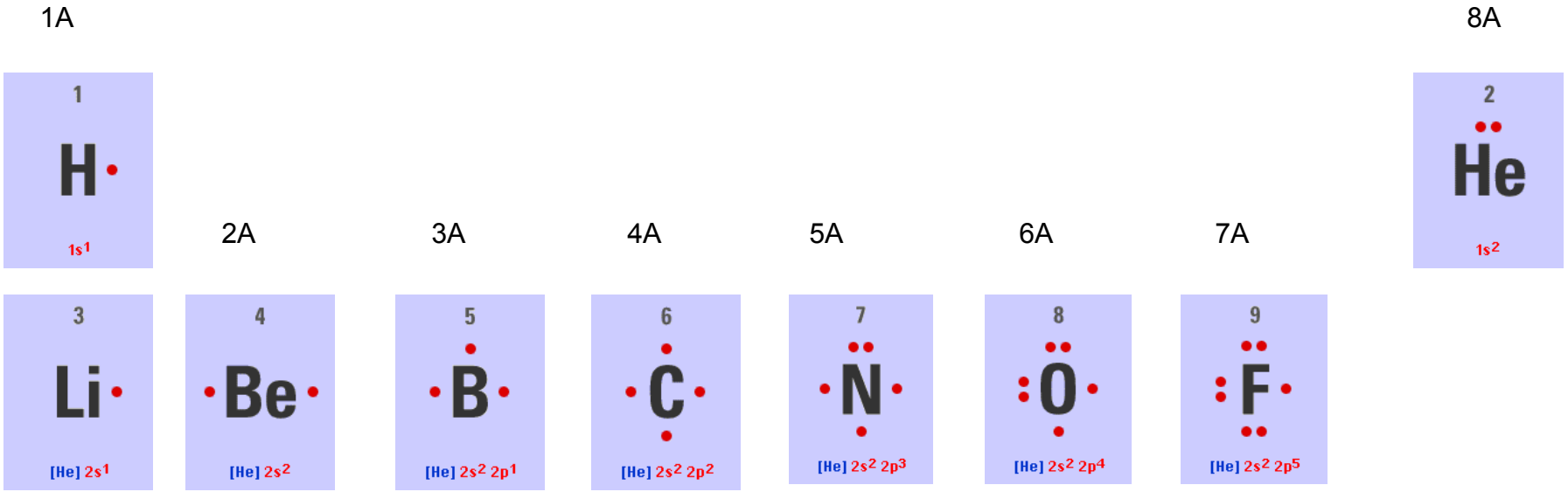
- Covalent: electrons are shared between two atoms
- Metallic: electrons flow through a lattice of atoms
- Ionic: electrostatic attractions between ions



Models of Molecular Bonding

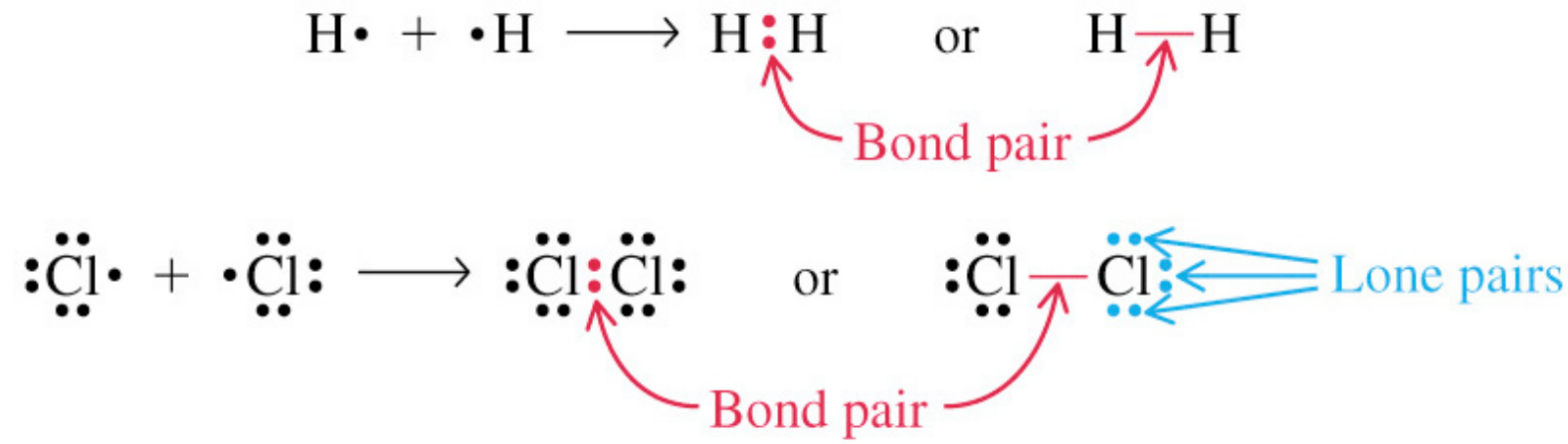
1. Lewis Dot Structures
2. VSEPR
3. Hybridization
4. Molecular Orbital Theory

Valence Electrons



Lewis Structures – A review

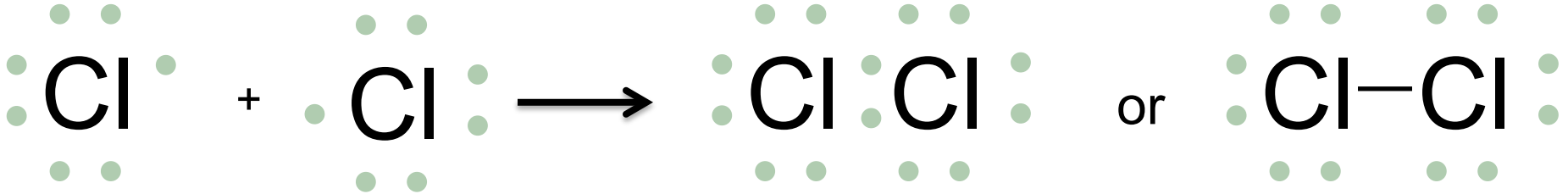
- Electrons are distributed as shared or BOND PAIRS and unshared or LONE PAIRS
  - line = bond
  - electron = •



Drawing Lewis Structures

The Octet Rule:

- bonds form when atoms have a full « octet », i.e. 8 valence electronsa



7 valence e$^-$ 7 valence e$^-$

Exceptions to the Octet Rule

- rules works best with 1st row elements
- 3 types of exceptions:
  - les than 8 valence electrons (incomplete octet)
  - odd number of valence electrons
  - more than 8 valence electrons (expanded octet)

Drawing Lewis Structures

1. Count the total number of valence electrons
   - add one e^- for each negative charge
   - subtract one e^- for each positive charge
2. Draw the molecule using single bonds
3. Count e^-'s used in each bond → subtract from total
4. Add leftover e^-'s to the structure
   - most e/n atoms first, stop when octets are full
5. Make double and triple bonds to complete octets
   - minimize formal charges

Examples : Drawing Lewis Structures

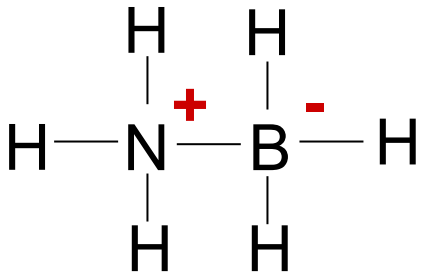
1. NH_3

2. XeF_4

3. CO_2

Formal Charges

- different than δ+ and δ-, these are caused by an excess or lack of electrons on a particular atom



- should always be minimized as much as possible
- generally put _____ on more EN atoms and _____ on less EN atoms

How to calculate formal charges

formal charge = # valence e^- in the free atom − # lone pair e^- on the atom − number of bonds to that atom

overall charge = $\sum$ formal charges

Examples: Formal Charges

1. CO

2. CO_3^{2-}

Your Turn…

What is the formal charge on the N atom in NH_4^+?

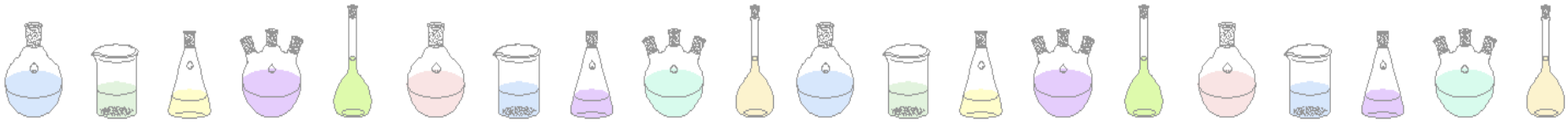
A. +2

B. +1

C. 0

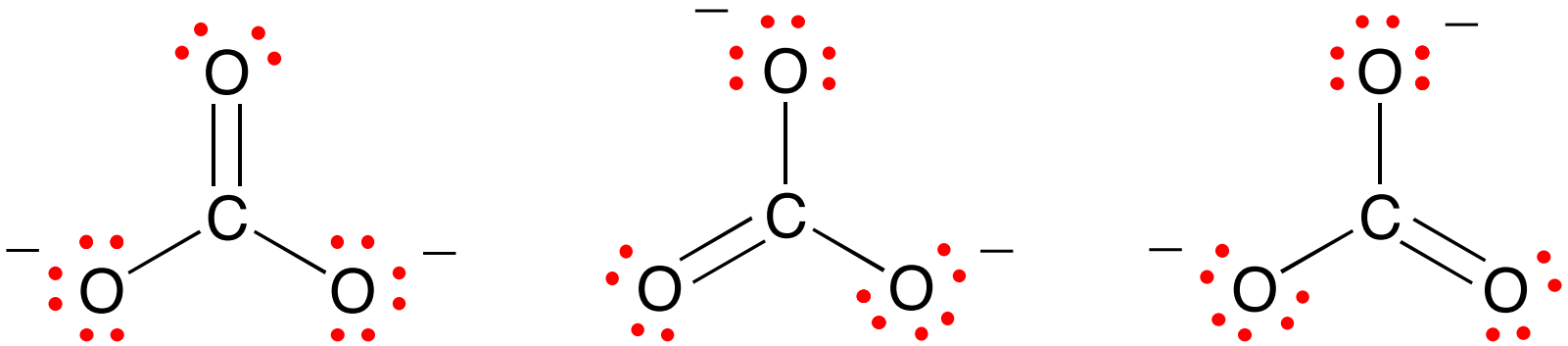
D. –1

E. –2

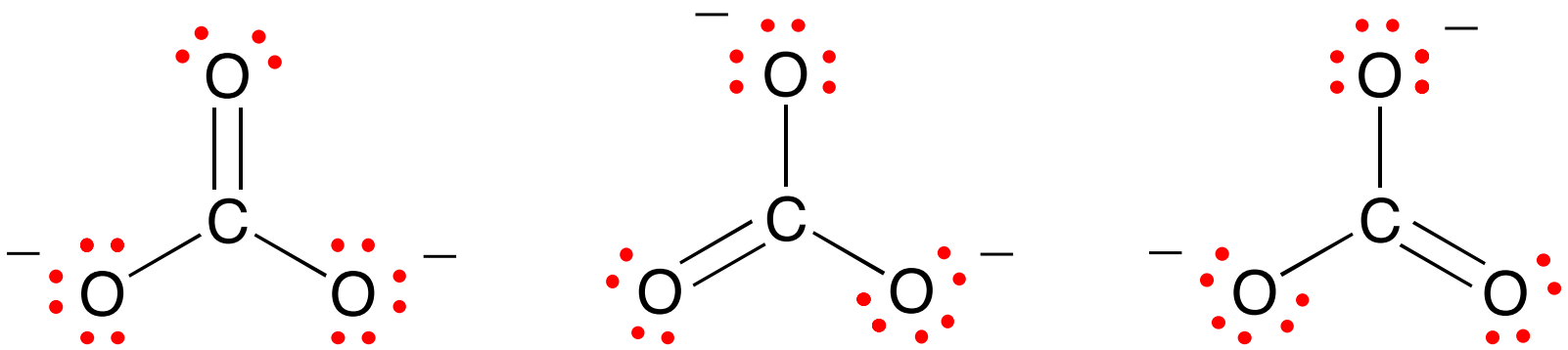


Resonance Theory

The Lewis structure of CO_3^{2-} can be drawn three ways:

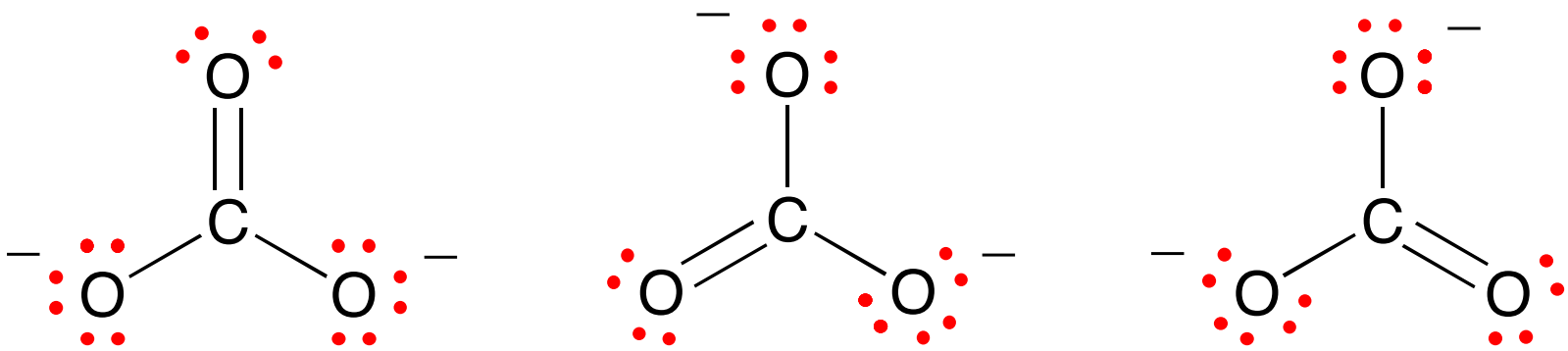


Resonance Theory



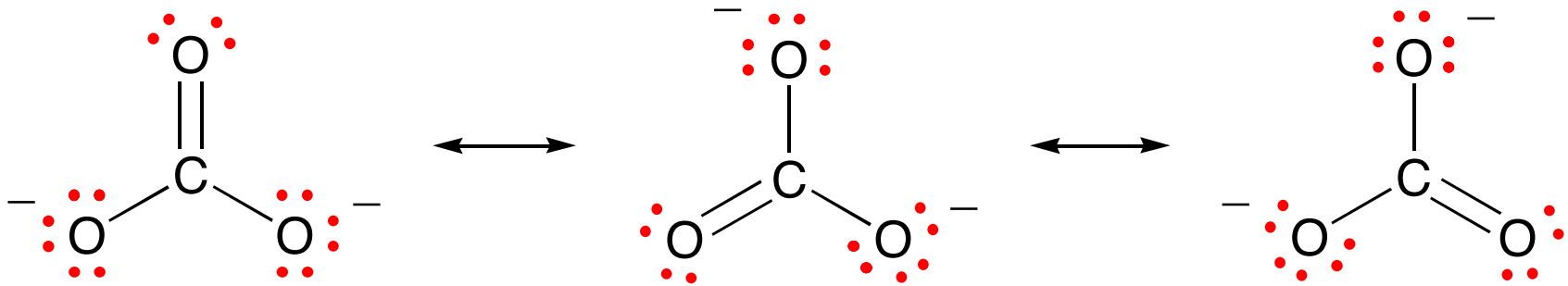
- expt'l data: all three C–O bonds are identical
- actual structure is thus a composite of these three possibilities → **RESONANCE HYBRID**
- indicate resonance structures using a double-headed arrow

Resonance Theory



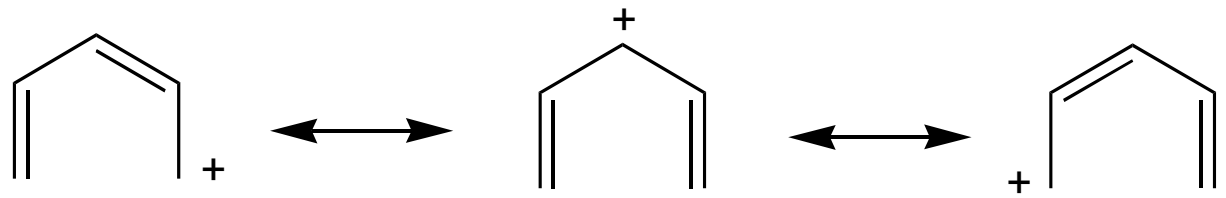
Equivalent vs. Non-equivalent Resonance Structures

- if multiple resonance structures are of the same energy, then they are EQUIVALENT
- each structure contributes equally to the overall resonance hybrid



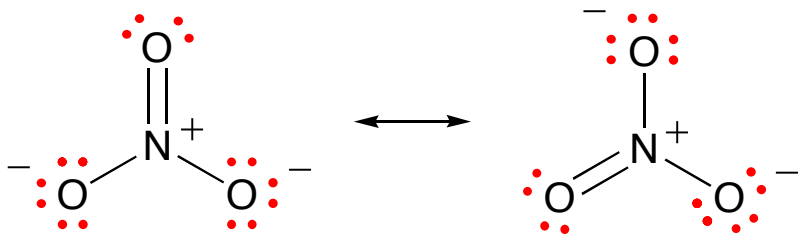
Equivalent vs. Non-equivalent Resonance Structures

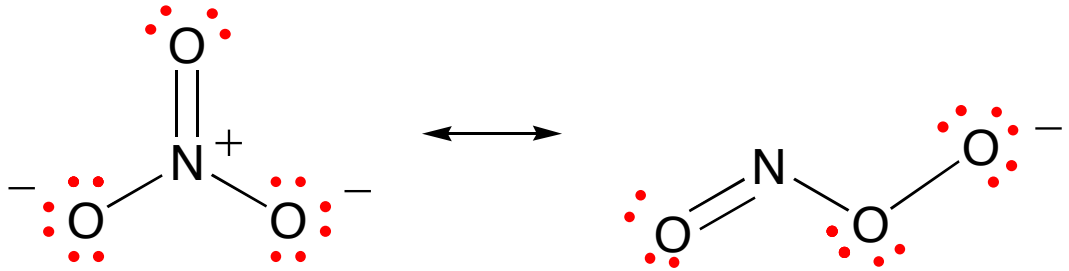
- if resonance structures are of differing energy, then they are NON-EQUIVALENT
- each structure contributes differently to the overall resonance hybrid



Drawing Resonance Structures

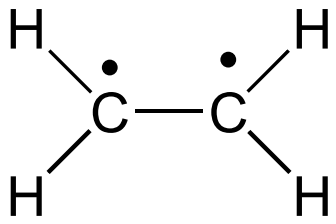
Rule 1 : only move electrons (NEVER atoms!)

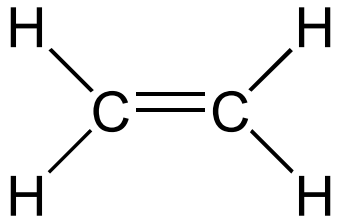




Drawing Resonance Structures

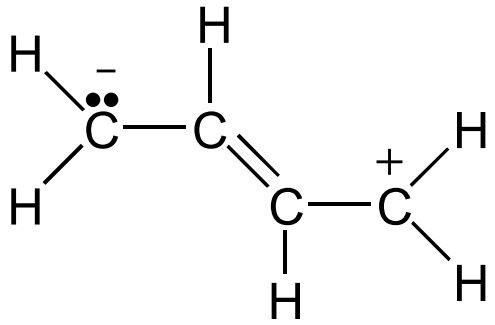
Rule 2 : maximize bonds and complete octets!

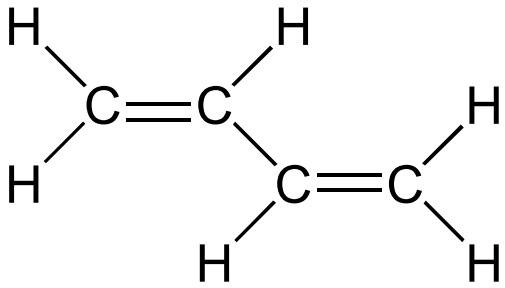




Drawing Resonance Structures

Rule 3 : maximize bonds and minimize formal charges!

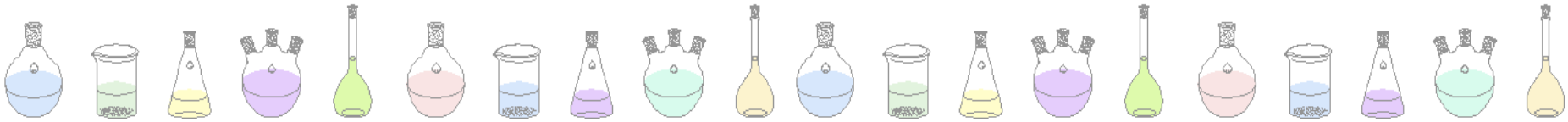




Drawing Resonance Structures

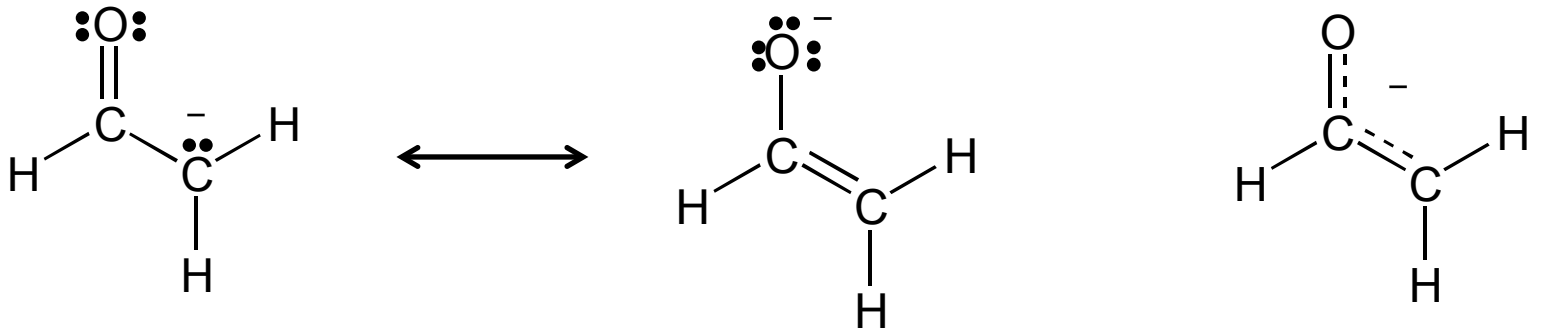
Rule 4 : negative formal charges on more electronegative atoms is best!

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794	2 2A																2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (272)		114 (287)		116 (289)		118 (293)



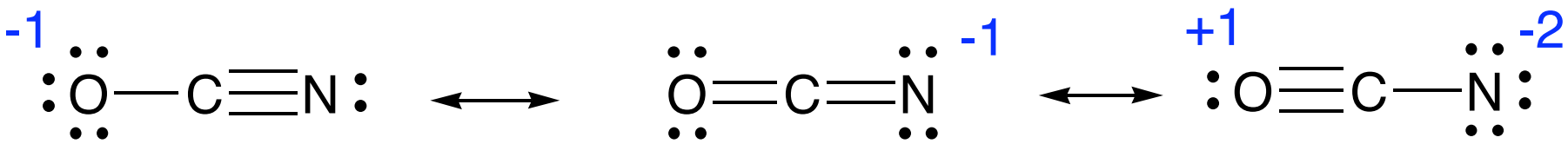
Drawing Resonance Structures

Rule 4 : negative formal charges on more electronegative atoms is best!



Your Turn…

Of the following resonance structures, which is the most favorable?



A **B** **C**

Section 8.6 Key Concepts

1. Lewis Structures
2. Formal Charges
3. Resonance Structures
4. Resonance Hybrids

Section 8.6 Suggested Problems

8.71, 8.73, 8.75, 8.77, 8.79,

8.81, 8.85, 8.87, 8.91, 8.94