

Chapter 6 CHEMICAL PERIODICITY

Effective nuclear charge -

Shielding -

GENERALIZATIONS about atomic behavior & properties

(1) Atomic radii (size)

Across a period, from left to right

Down a group, from top to bottom

(2) Ionization Energy (IE) - the minimum amount of energy required to remove outermost electron(s) from an atom

$A \rightarrow A^+ + e^-$ 1st ionization energy

$A^+ \rightarrow A^{2+} + e^-$ 2nd ionization energy

Across a period, from left to right

Down a group, from top to bottom

(3) Electron Affinity (EA) - energy absorbed when an atom gains an electron

$A + e^- \rightarrow A^-$ Energy released - exothermic, negative number.
Most negative refers to element most likely to gain an e-.

Across a period, from left to right

Down a group, from top to bottom

(4) Ionic Radii (size)

for atoms of SAME CHARGE, trend is exactly the same as atomic radii

cations are SMALLER than neutral atom: Na^+ Na

anions are LARGER than neutral atom: F F^-

Cs^+ F^-

increasing + charge: Cr^+ Cr^{2+} Cr^{3+}

*(5) Electronegativity * (EN) - the relative tendency of an atom to attract electrons to itself when chemically combined with another atom ("pull")

ex. NaCl , Na^+ & Cl^- ions electron is *transferred* from Na to Cl
 metal/nonmetal

ex. SO_3 covalent bonds electron is shared *unequally* between
 nonmetal/nonmetal S and O
 electron pair sharing

Across a period, from left to right

Down a group, from top to bottom

How to memorize:

Dr. Heising's method for Lewis Dot Structures

Note: These rules **will not work** if

- a) **hydrogen** is present in the molecule, as H does not obey the octet rule
- b) the molecule has **more than one central atom**

If the molecule falls into one or both of these categories, flip over for some alternate ways to get the Lewis structure.

1. Add up the valence electrons. Remember the charge (subtract for +, add for -).
2. Divide by eight. The *integer* is the number of sigma (σ) bonds around the central atom. The *remainder* (if any) is the number of electrons around the central atom.
3. Arrange the atoms with the least electronegative atom at the center. Symmetric is often (but not always) correct.
4. Draw the sigma (σ) bonds. Should be equal to the *integer* in step 2, and every atom should have one bond to the central atom by the time you are finished.
5. Put the *remainder* electrons as lone pairs on the central atom. If there are an odd number of electrons (infrequent but not impossible), just put the odd one by itself.
6. Does the central atom have 8 electrons around it? Include electrons in bonds and electrons in lone pairs in the count. If it has less than 8, make additional bonds, called pi (π) bonds, with the surrounding atoms to complete the octet. More than 8 electrons is OK for atoms in row 3 or higher of Periodic Table.
7. Fill the octets of the surrounding atoms using electron pairs.
8. Check yourself. Count the total # of electrons in bonds and lone pairs in the entire molecule. It should match the value you found in step 1.
9. Calculate the formal charge on the central atom. Choose the resonance structure with the least formal charges as your best answer. If central atom is in row 3 or higher, you may expand the octet with additional π bonds to minimize the formal charge.

The method must be modified if

a) Hydrogen is present.

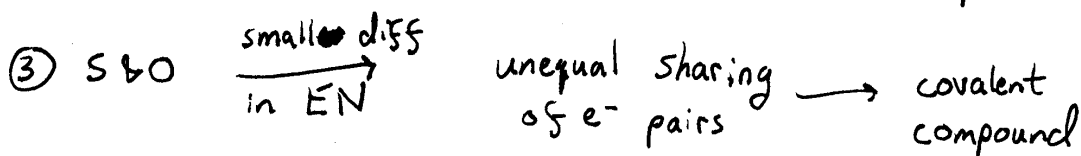
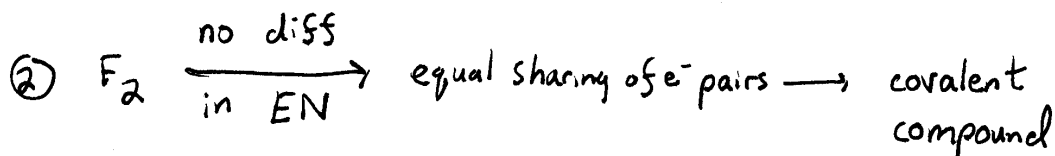
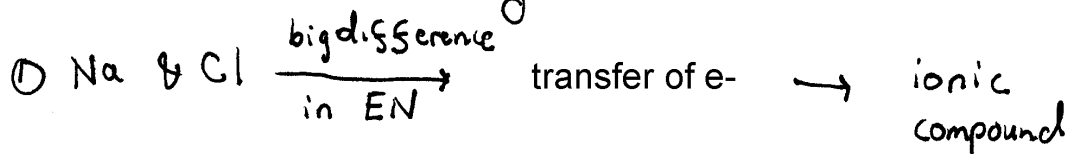
- To which atom is the hydrogen connected? Often H is bonded to the atom next to it in the chemical formula. Ex.
 - o CHCl_3 has one H bonded to C, the central atom
 - o HCO_2H has one H bonded to C (central atom) and one H bonded to O.
 - o In ternary oxoacids, (H_2SO_4 , H_3PO_4 , HNO_3 , etc.) H is bonded to O.
- Substitute a minus charge in the formula for every H present. For example, $\text{CHCl}_3 \rightarrow \text{CCl}_3^-$, $\text{H}_3\text{CCN} \rightarrow \text{CCN}^{3-}$, $\text{HCO}_2\text{H} \rightarrow \text{CO}_2^{2-}$
- Follow the rules. After step 8, substitute a sigma bond to an H atom for one lone pair (each) on the appropriate atom. Avoid putting H on O atoms that form π bonds.

b) the structure has more than one 'central' atom.

- If the extra atom not bonded to the central atom is just hydrogen (Ex., H_2SO_4 , H_3PO_4 , etc.), follow the directions in method a).
- Diatomic molecules (ex. N_2 , O_2 , Cl_2). Follow the book, or treat BOTH as central atoms. Complete octet with π bonds.
- Otherwise (organic molecules, $\text{P}_2\text{O}_7^{4-}$), follow the method in the book, or do the following:
 - o Do steps 1, 3, and 4. As there is more than one central atom, arrange the atoms in the most symmetric manner possible.
 - o Subtract bonding electrons (step 4) from valence electrons (step 1). Distribute remainder over the peripheral atoms until the octet rule is fulfilled for all atoms (except H, of course).
 - Some left over – put as lone pairs on central atoms
 - Not enough – go back and turn some of the lone pairs into π bonds.
 - o Do steps 8 and 9.

Ch.7 Chemical Bonding

(1)

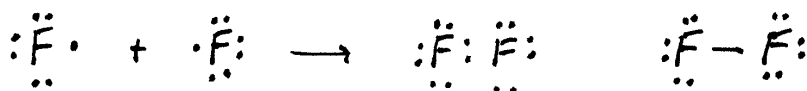


Valence electrons - outermost s & p electrons in an atom

Octet rule - elements achieve stability when they possess (or share) 8 valence e⁻

noble gases (except He) - 8 valence e⁻

pictorial representation - Lewis dot formula (Table 7.1)



.. electron pair (lone pair)

— bond (shared pair e⁻) Lewis dot structure

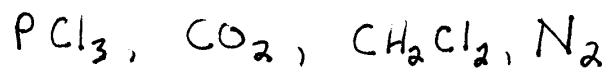
can predict arrangement of atoms in molecules.



1 bond = sigma
2nd = pi

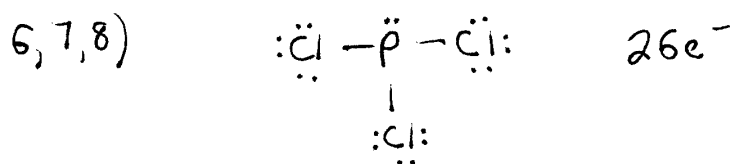
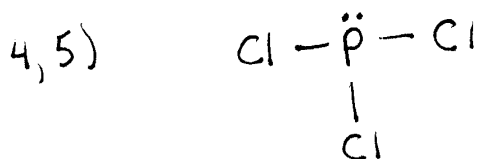
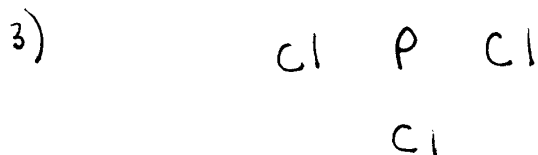
need method for more complicated arrangements.

Determine Lewis structures for the following examples:



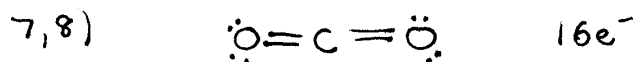
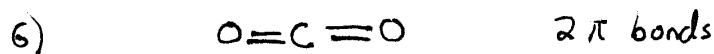
$$\begin{array}{l} \text{P} : s^2 p^3 = 5 \\ \text{Cl} : s^2 p^5 = 3(7) \\ \hline 26e^- \end{array}$$

2) $26/8 = 3$ w/ $2e^-$ left 3 σ bonds & 1 lone pair



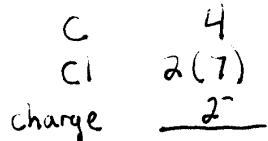
$$\begin{array}{l} \text{C} : 4 \\ \text{O} : 2(6) \\ \hline 16e^- \end{array}$$

2) $16e^- / 8 = 2 \sigma$ bonds



CH_2Cl_2 - has hydrogen! (violates octet rule)

- remove H & add - charge. put H back @ 8 (step).



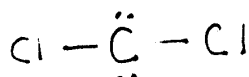
$$20e^- / 8 = 2 \text{ w/ } 4e^-$$

2 σ bonds

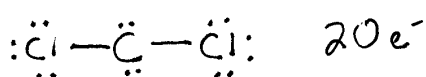
2 lone pairs

2)

3,4,5)



6,7,8)



* put H back in.

