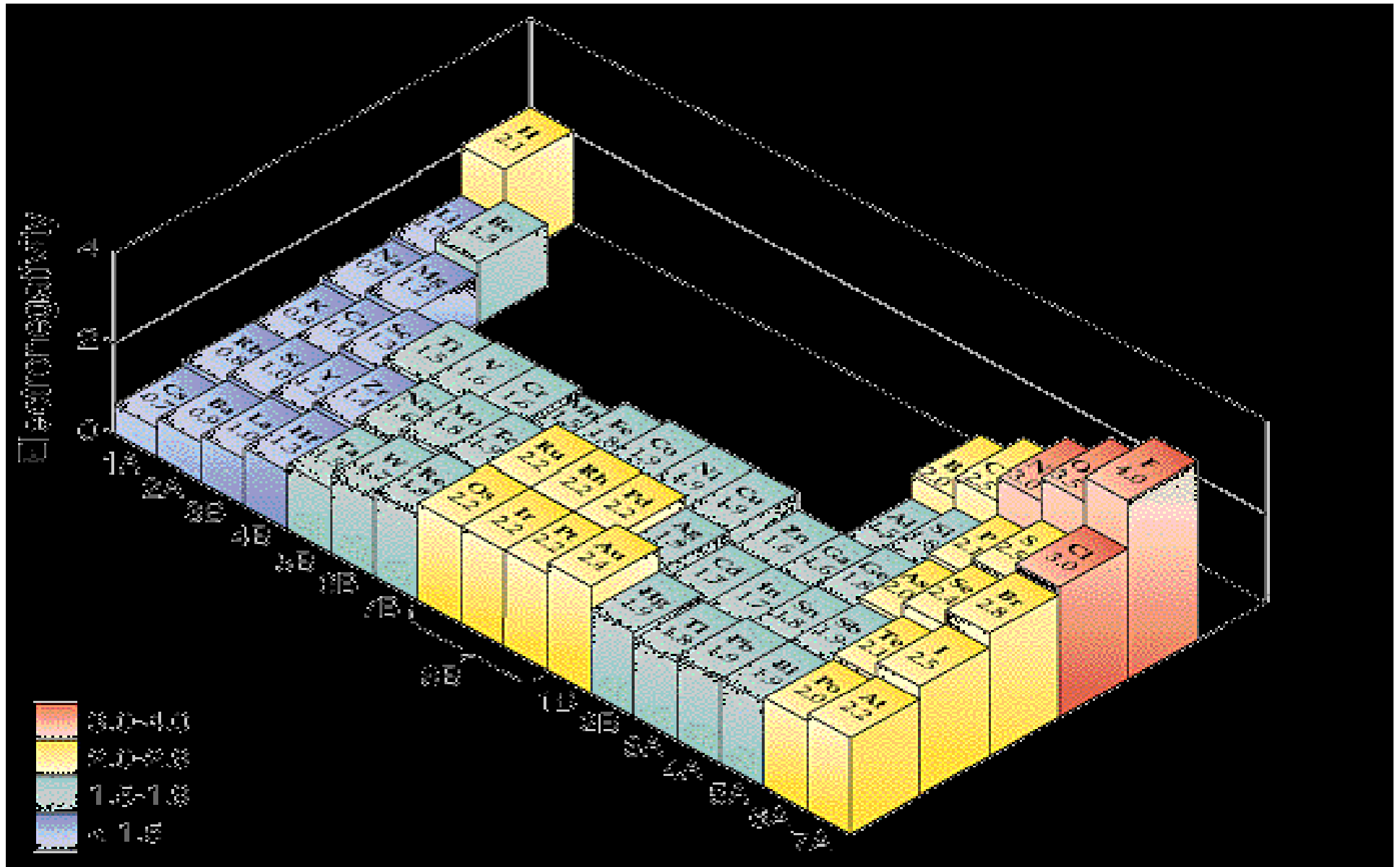


ELECTRONEGATIVITY CHART:



Fuzzy borders between Ionic and Covalent bonding:

ionic and polar covalent bonding:

<http://www.youtube.com/watch?v=Kj3o0XvhVqQ&feature=related>

LARGE difference in Electronegativities - → ionic bond

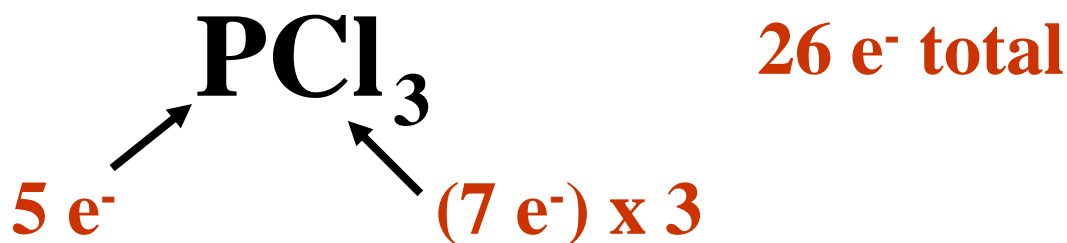
SMALL difference in Electronegativities -→ polar covalent

No difference (same element atoms) → non-polar covalent

Can be estimated to some extent from position of elements in periodic table.
To be exact – need to have access to the exact values of Electronegativities.

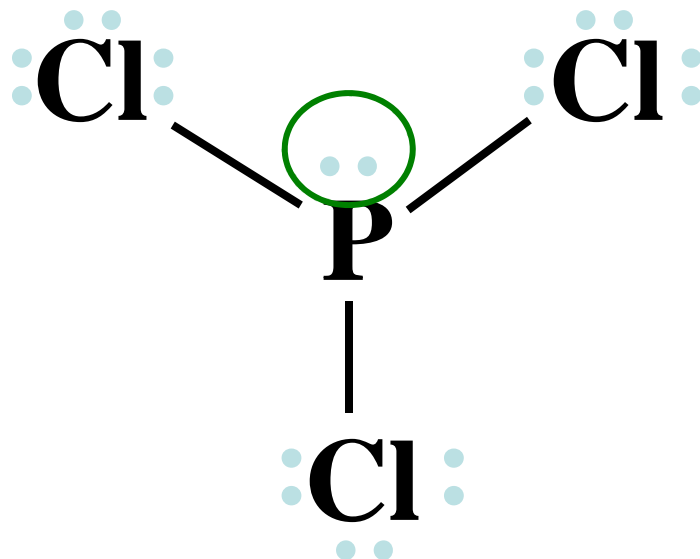
Writing Lewis Dot Formulas

- **Step 1:** Total all valence electrons in the molecular formula. That is, total the group numbers of all the atoms in the formula.



- For a polyatomic anion, add the number of negative charges to this total.
- For a polyatomic cation, subtract the number of positive charges from this total.

Writing Lewis Dot Formulas



Try SCl_2
and SiOCl_2

- **Step 1:** Total all valence electrons in the molecular formula. That is, total the group numbers of all the atoms in the formula.

For a polyatomic anion, add the number of negative charges to this total. For a polyatomic cation, subtract the number of positive charges from this total.

Step 2: Arrange the atoms radially, with the least electronegative atom in the center. Place one pair of electrons between the central atom and each peripheral atom.

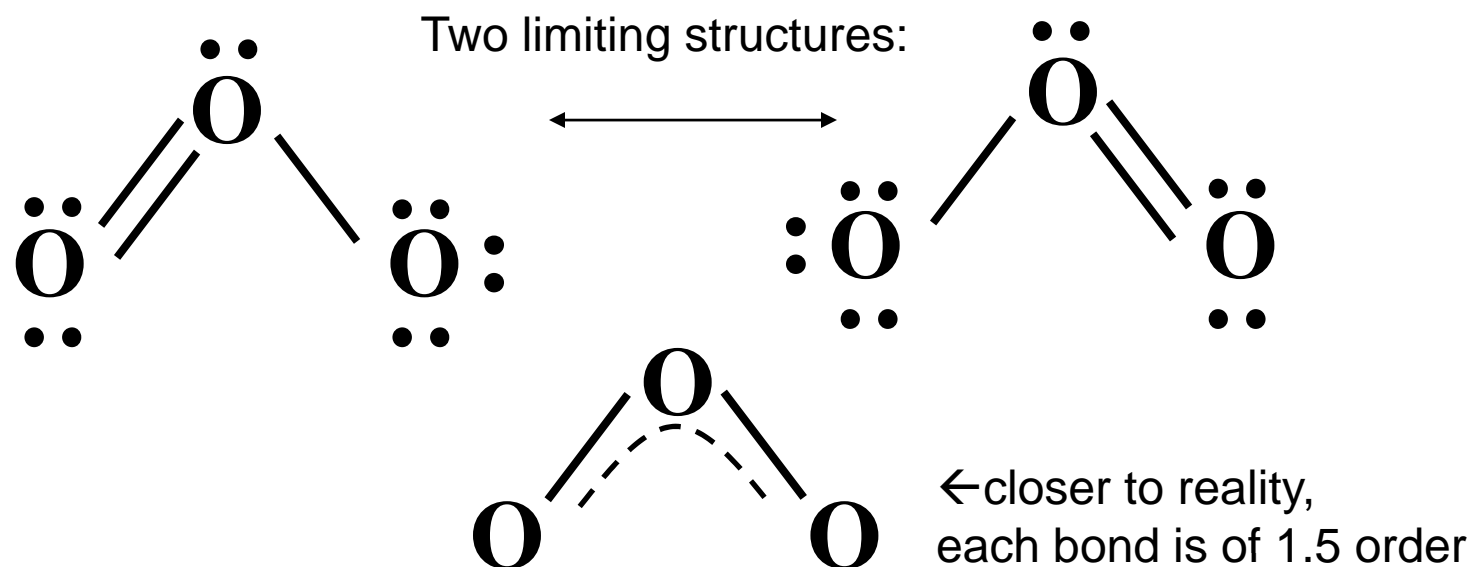
Step 3: Distribute the remaining electrons to the peripheral atoms to satisfy the octet rule.

- **Step 4:** Distribute any remaining electrons to the central atom. If there are fewer than eight electrons on the central atom, a multiple bond may be necessary.

Delocalized Bonding: Resonance

The structure of ozone, O_3 , can be represented by two different Lewis electron-dot formulas.

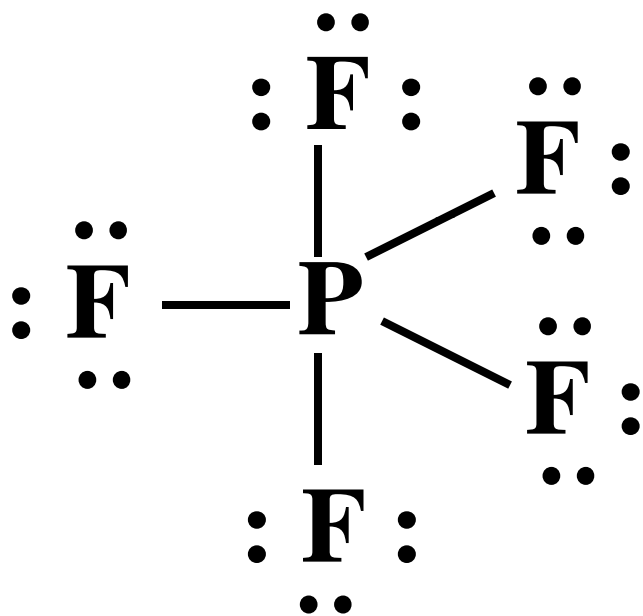
- Experiments show, however, that both bonds are identical. According to theory, one pair of bonding electrons is spread over the region of all three atoms.
- This is called **delocalized bonding**, in which a bonding pair of electrons is spread over a number of atoms.



TRY CO_3^{2-} ion. What order is C-O bond here?

Exceptions to the Octet Rule

Generally, if a nonmetal is *in the third period or greater* it can accommodate as
These elements have unfilled “d” subshells that can be used for bonding.



Try XeF₄

10 e on phosphorous

But no NF₅ exist. Why?

Formal Charge and Lewis Structures.

Which structure is better?



The formal charge (FC) of an atom is determined by subtracting the number of electrons in its “domain” from its group number.

$$\text{FC} = \text{group number} - (\text{all nonbonding } e + 1/2 \text{ of bonding } e)$$

The most likely structure is the one with the least number of atoms carrying formal charge. If they have the same number of atoms carrying formal charge, choose the structure with the negative formal charge on the more electronegative atom.

So which one is better?

Bond Length and Bond Order

- The **bond order**, determined by the Lewis structure, is the number of pairs of electrons in a bond.

Bond length depends on bond order.

As the bond order increases, the bond gets **shorter and stronger**.

	Bond length	Bond energy
C—C	154 pm	346 kJ/mol
C=C	134 pm	602 kJ/mol
C≡C	120 pm	835 kJ/mol

What is bond order in O₂? Cl₂? N₂? N₂F₂?

Table 9.5**Bond Energies (in kJ/mol)***

		Single Bonds								
		H	C	N	O	S	F	Cl	Br	I
H	432									
C	411	346								
N	386	305	167							
O	459	358	201	142						
S	363	272	–	–	226					
F	565	485	283	190	284	155				
Cl	428	327	313	218	255	249	240			
Br	362	285	–	201	217	249	216	190		
I	295	213	–	201	–	278	208	175	149	

		Multiple Bonds				
C=C	602	C=N	615	C=O	745 (799 in CO ₂)	
C≡C	835	C≡N	887	C≡O	1072	
N=N	418	N=O	607	S=O (in SO ₂)	532	
N≡N	942	O=O	494	S=O (in SO ₃)	469	

*Data are taken from J. E. Huheey, Keiter, and Keiter, *Inorganic Chemistry*, 4th ed. (New York: HarperCollins, 1993), pp. A21–A34.

BOND ENERGY and Reaction Enthalpies:

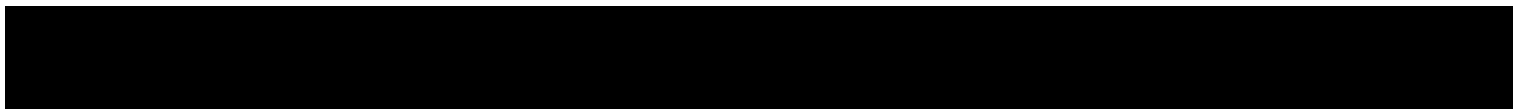
- We define the atomic A-B **bond energy** (denoted BE) as the average **enthalpy** (~energy) change for the breaking of an A-B bond in a molecule in its gas phase.
- BE (A-B) is energy change for the process $A-B (g) \rightarrow A (g) + B (g)$
- BE are tabulated in reference tables (page above).
- This allows to estimate the enthalpy of the reaction ΔH (that is ~ net energy change due to the reaction, - which can be positive or negative!)

- The enthalpy, ΔH , of a reaction is approximately equal to the **sum of the bond energies of the reactants minus the sum of the bond energies of the products**

Example:

Lets estimate ΔH for this reaction using the table above:





1 – show Lewis structures:

2 -estimate how many bonds broken:

3- how many bonds made:

4- look up values and calculate the difference: (all bonds made – all bonds broken)


$$\Delta H = \text{BE}(\text{C} - \text{H}) + \text{BE}(\text{Cl} - \text{Cl}) - \text{BE}(\text{C} - \text{Cl}) - \text{BE}(\text{H} - \text{Cl})$$

$$\Delta H = (411 + 240 - 327 - 428) \text{ kJ}$$

$$\Delta H = -104 \text{ kJ}$$

Operational Skills for Ch 9

- Using Lewis symbols to represent ionic bond formation.
- Writing electron configurations of ions.
- Using periodic trends to obtain relative ionic radii.
- Using electronegativities to obtain relative bond polarity.
- Writing Lewis formulas.
- Writing resonance structures.
- Using formal charges to determine the best Lewis formula.
- Relating bond order and bond length.
- Estimating ΔH from bond energies.