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CHEMICAL BONDING

REVIEW: VALENCE ELECTRONS

- What are valence electrons?

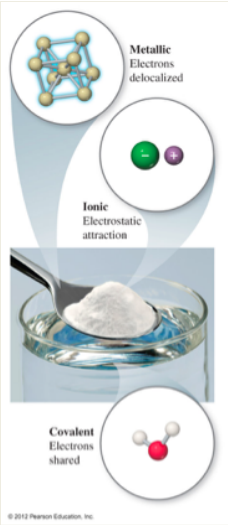
- Which groups on the periodic table readily give up electrons? What group readily accepts electrons?

CHEMICAL BONDS:

- What are chemical bonds?

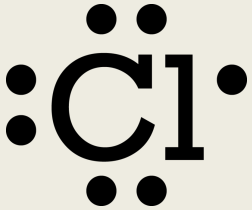
- Three Basic Types of Bonds:

1. _____
2. _____
3. _____



LEWIS SYMBOLS:

- What are Lewis Dot Structures?



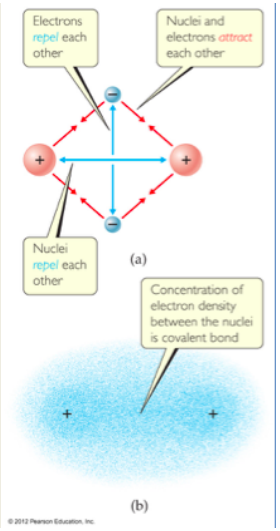
- When forming compounds, atoms tend to _____electrons until they are surrounded by eight valence electrons (the octet rule).

TYPES OF BONDS: IONIC

- What happens when you have ionic bond?

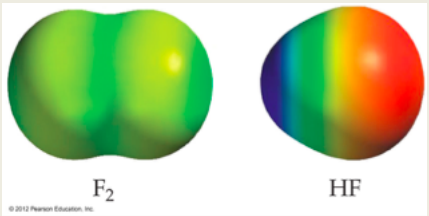
TYPES OF BONDS: COVALENT

- What happens when you have a covalent bond?
- Several electrostatic interactions happen in these bonds, for example…



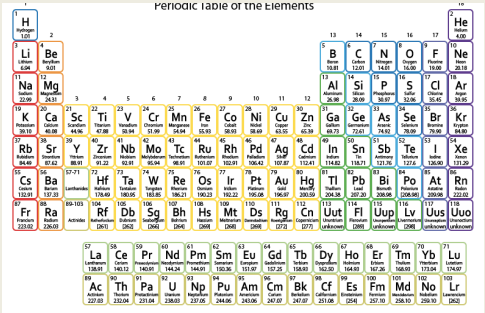
POLAR COVALENT BONDS:

- What does it mean when a covalent bond is *polar*?



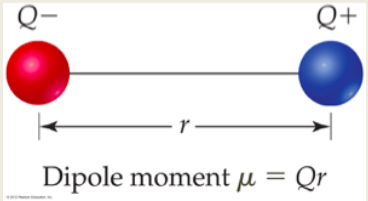
REVIEW: ELECTRONEGATIVITY

- What is electronegativity?
- What is the periodic trend for electronegativity?



POLAR COVALENT BONDS:

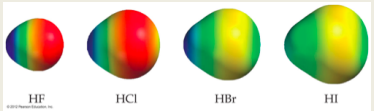
- When two atoms share electrons unequally, a _____ _____ results.



POLAR COVALENT BONDS:

Compound	Bond Length (Å)	Electronegativity Difference	Dipole Moment (D)
HF	0.92	1.9	1.82
HCl	1.27	0.9	1.08
HBr	1.41	0.7	0.82
HI	1.61	0.4	0.44

- The greater the difference in electronegativity, the _____ the dipole moment. *If the difference is too great it is an ionic bond.*



HOW DO WE KNOW IF THE BOND IS IONIC, NON-POLAR COVALENT, OR POLAR COVALENT?

Electronegativity Difference	Bond Type
0 - 0.4	Non-polar covalent
0.5 - 1.0	Moderately polar
1.1 – 1.9	Polar covalent
>2.0	Ionic Bond

EXAMPLE PROBLEM #1: PC, NPC, I?

- Describe what type of bonds each of the following would exhibit:

1. Chlorine and Bromine
2. Potassium and Fluorine
3. Nitrogen and Oxygen
4. Magnesium and Phosphorus

DIFFERENCES BETWEEN…

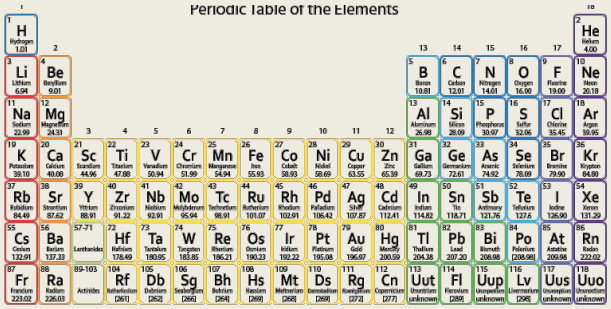
IONIC BONDS:

COVALENT BONDS:

LEWIS STRUCTURES:

- What are Lewis Structures?

REVIEW: HOW MANY VALENCE ELECTRONS?



STEPS TO WRITING LEWIS STRUCTURES:

1. Find the sum of the valence electrons
2. Central atom is the least electronegative. Connect the outer atoms by single bonds. Subtract used electrons.
3. Fill the octets of the outer atoms. Subtract used electrons.
4. Fill the octet of the central atoms. Subtract used electrons.
5. If you run out of the electrons before the central atom has an octet form multiple bonds.

STEP 1:

- Find the sum of valence electrons of all atoms in the polyatomic ion or molecules.
  - If it is an anion…

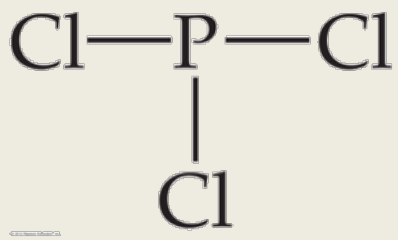
    _____
  - If it is a cation…

    _____

PCl_3

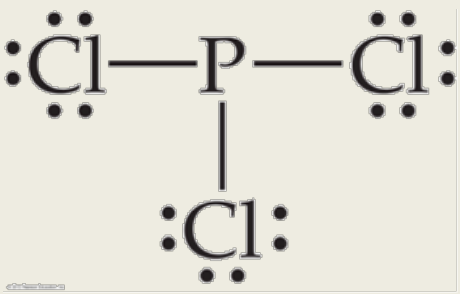
STEP 2:

- The central atom is the least electronegative element that ISN'T hydrogen. Connect the outer atoms to it by _____ bonds.



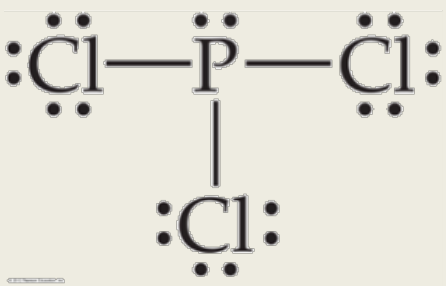
STEP 3:

- Fill the octets of the outer atoms.



STEP 4:

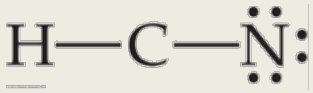
- Fill the octet of the central atom.



If you do not have enough electrons to fill the octet of the central atom… continue on to STEP 5!

STEP 5 :

- DO THIS STEP ONLY IF YOUR CENTRAL ATOM DOESN'T HAVE A FULL OCTET AND YOU DO NOT HAVE ENOUGH ELECTRONS TO FILL IT.
- If you run out of the electrons allowed before the central atom has an octet…



- … form multiple bonds until it does.

TRY THIS…

- Create the Lewis Structure for C_2H_4

EXAMPLE PROBLEM #2: LEWIS STRUCTURES

- Create a Lewis dot structure for sulfur trioxide.

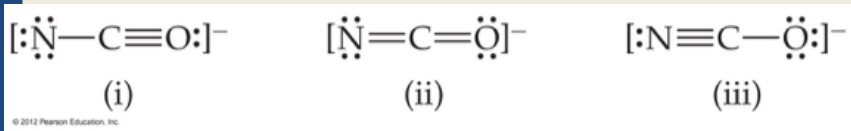
FORMAL CHARGE OF LEWIS DOT STRUCTURES:

- Once you finish the Lewis dot structure, find the _____.
- FC = Valence Electrons – (LP + (1/2BP))
- For example… Let's look at the two structures of CO_2

FORMAL CHARGE OF LEWIS DOT STRUCTURES:

- The best structure will meet the following criteria:

- (1) It is the one with the _____ charges.
- (2) Puts a negative charge the _____ electronegative element.
- For example, which of the following Lewis dot structures is best?

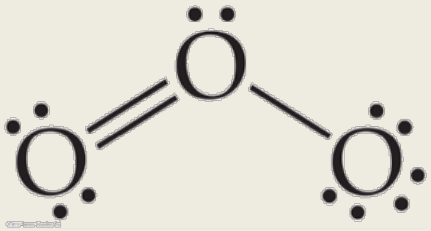


EXAMPLE PROBLEM #3 : FIND THE FORMAL CHARGE

- Draw the Lewis Dot Structure for CH_2O. Determine the formal charges on each element.

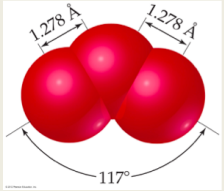
RESONANCE IN LEWIS DOT STRUCTURES:

- Do you think that this is the MOST accurate picture for Ozone, O_3….



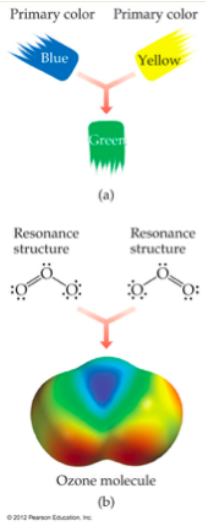
RESONANCE IN LEWIS DOT STRUCTURES:

- What is resonance?



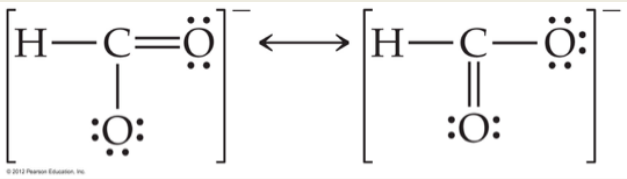
RESONANCE IN LEWIS DOT STRUCTURES:

- Just as green is a synthesis of blue and yellow…
- Ozone is a synthesis of these two resonance structures.



RESONANCE IN LEWIS DOT STRUCTURES:

- What is the difference between localized and delocalized electrons?

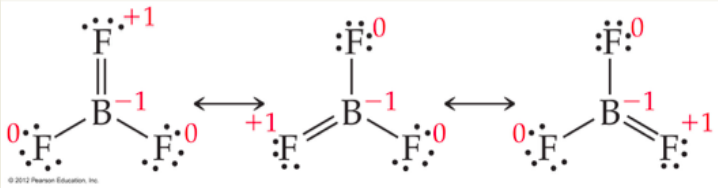


IT WOULDN'T BE CHEMISTRY IF THERE AREN'T EXCEPTIONS!

- Exceptions to the Octet Rules:
  1. Ions or molecules with an _____ number of electrons.
  2. Ions or molecules with _____ than an octet.
  3. Ions or molecules with _____ than eight valence electrons (an expanded octet).

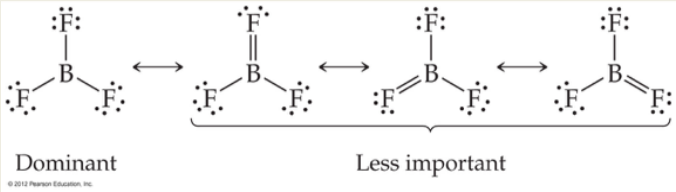
EXCEPTION 1: FEWER THAN 8 ELECTRONS

- For example, BF_3…



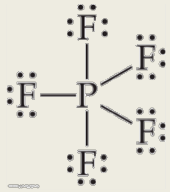
EXCEPTION 1: FEWER THAN 8 ELECTRONS

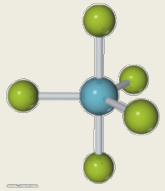
- Therefore, structures that put a double bond between boron and fluorine are much less important than the one that leaves boron with only 6 valence electrons.



EXCEPTION 2: MORE THAN 8 ELECTRONS

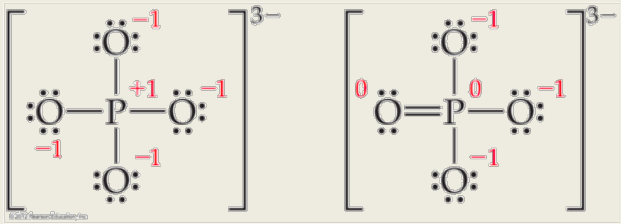
- The only way PF_5 can exist is if phosphorus has 10 electrons around the center
- It is allowed to expand the octet of atoms on the _____row or below. Why does this happen?





EXCEPTION 2: MORE THAN 8 ELECTRONS

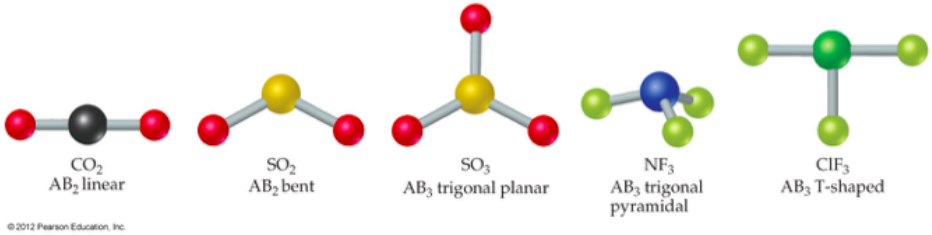
For another look at the phosphate ion (PO_4^{3-})…



The less ion this… When the central atom is on the third row or below and expanding its octet _____ some formal charges, do so.

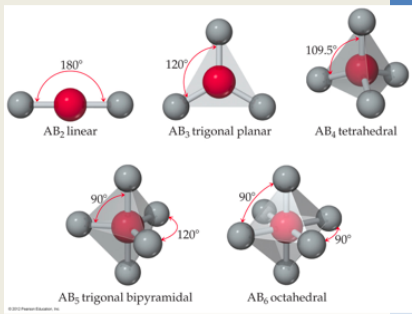
MOLECULAR SHAPES:

Why is the shape of the molecule important?



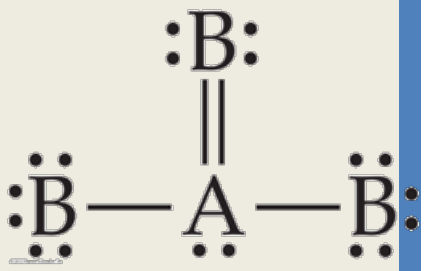
MOLECULAR SHAPES:

- What determines the shape of a molecule?

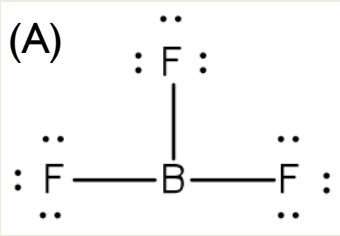


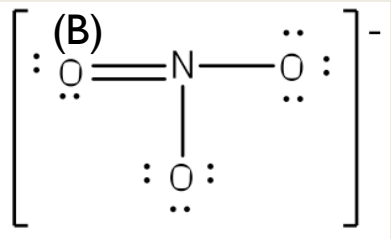
MOLECULAR SHAPES: ELECTRON DOMAINS

- What are electron domains?
- A double or triple bond counts as…
- A lone pair counts as…
- How many electron domains does the central atom have? _____



EXAMPLE PROBLEM #4 : ELECTRON DOMAINS



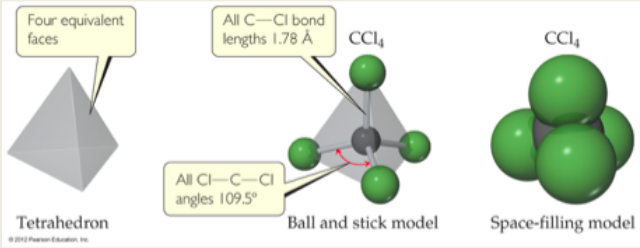


How many electron domains are in…

(A)_____ (B)_____

VALENCE-SHELL ELECTRON-PAIR REPULSION THEORY (VSEPR):

- What is VSEPR?



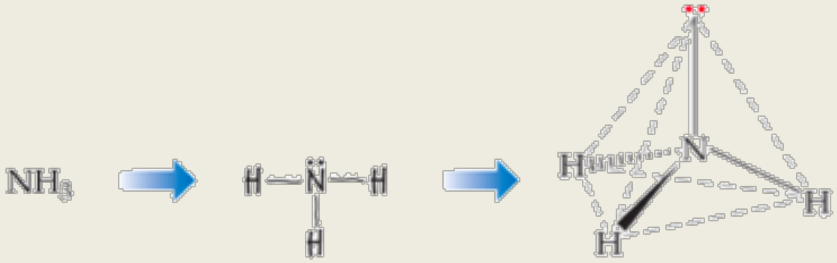
ELECTRON-DOMAN GEOMETRIES:

TABLE 9.2 Electron-Domain Geometries and Molecular Shapes for Molecules with Two, Three, and Four Electron Domains Around the Central Atom

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
2	Linear	2	0	Linear	$\ddot{O}=C=\ddot{O}$
3	Trigonal planar	3	0	Trigonal planar	
		2	1	Bent	
4	Tetrahedral	4	0	Tetrahedral	
		3	1	Trigonal pyramidal	
		2	2	Bent	

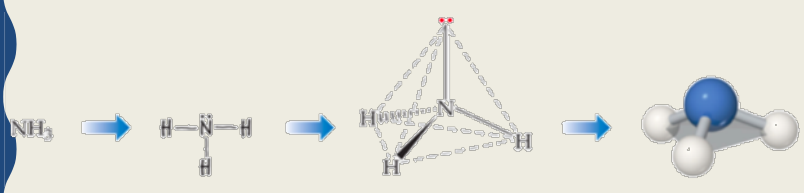
ELECTRON-DOMAIN GEOMETRIES:

- How do you determine the electron-domain geometries:



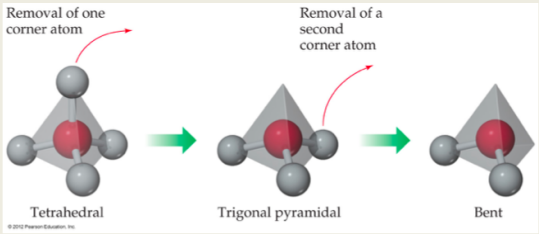
MOLECULAR GEOMETRIES:

- How are molecular geometries different than electron domain geometries?



MOLECULAR GEOMETRIES:

- Why is it important to note the molecular geometry instead of electron domain geometry?



LINEAR (2) ELECTRON DOMAIN:

- In a linear electron domain geometry, how many molecular geometries are possible? _____

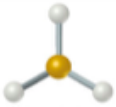
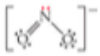
TABLE 9.2 • Electron-Domain and Molecular Geometries for Two, Three, and Four Electron Domains around a Central Atom

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
2	 Linear	2	0	 Linear	

- **NOTE**: If there are only two elements present, e.g. HCl, then the geometry is ALWAYS linear!

TRIGONAL PLANAR (3) ELECTRON DOMAIN:

TABLE 9.2 • Electron-Domain and Molecular Geometries for Two, Three, and Four Electron Domains around a Central Atom

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
3	 Trigonal planar	3	0	 Trigonal planar	
		2	1	 Bent	

TRIGONAL PLANAR (3) ELECTRON DOMAIN:

In a trigonal planar electron domain geometry, how many molecular geometries are possible? _____

What is the difference between the possibilities?

TETRAHEDRAL (4) ELECTRON DOMAIN:

TABLE 9.2 • Electron-Domain and Molecular Geometries for Two, Three, and Four Electron Domains around a Central Atom

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
4	 Tetrahedral	4	0	 Tetrahedral	
		3	1	 Trigonal pyramidal	
		2	2	 Bent	

TETRAHEDRAL (4) ELECTRON DOMAIN:

In a trigonal planar electron domain geometry, how many molecular geometries are possible? _____

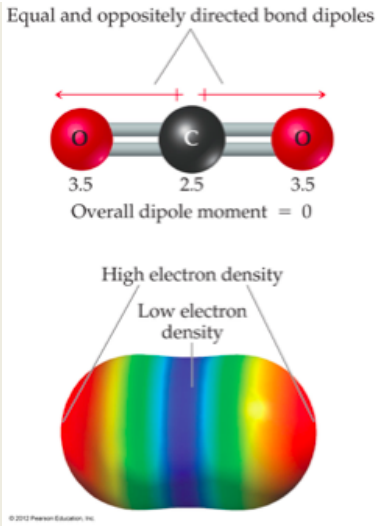
What is the difference between the possibilities?

EXAMPLE PROBLEM #5: GEOMETRIES

- Draw the Lewis dot structures and determine the molecular geometry of the following compounds:
- CF_4
- $AlCl_4^-$

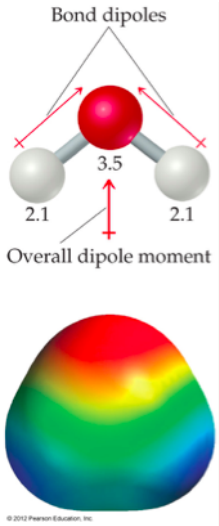
POLARITY:

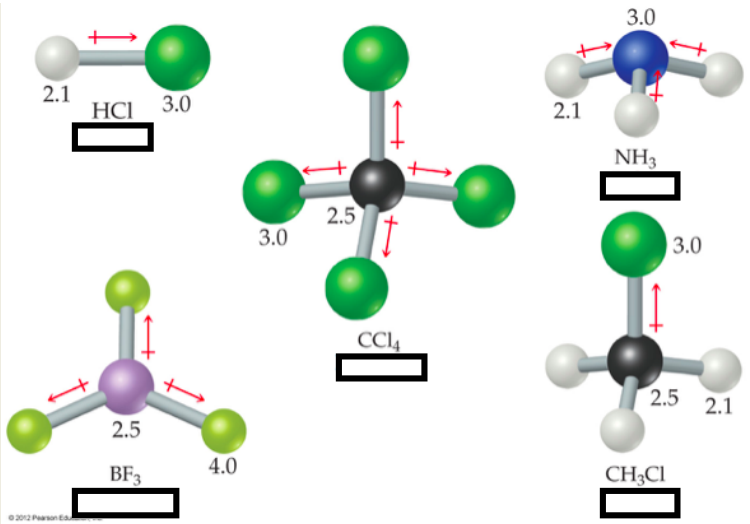
- REVIEW: What is polarity?



POLARITY:

- How do you look at a structure and determine if it is polar?





EXAMPLE PROBLEM #6: POLARITY

- Predict whether each of the following molecules has a dipole moment (polar or nonpolar)
- BrCl
- NF_3
- CH_2Cl_2
- SiS_2