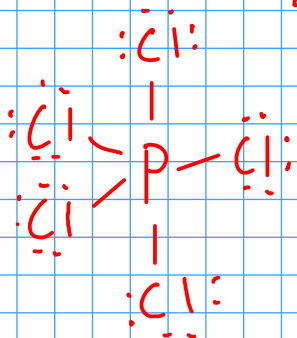
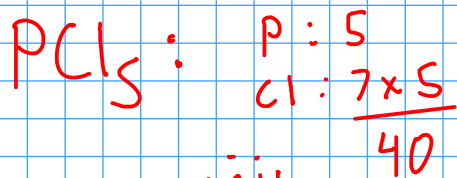
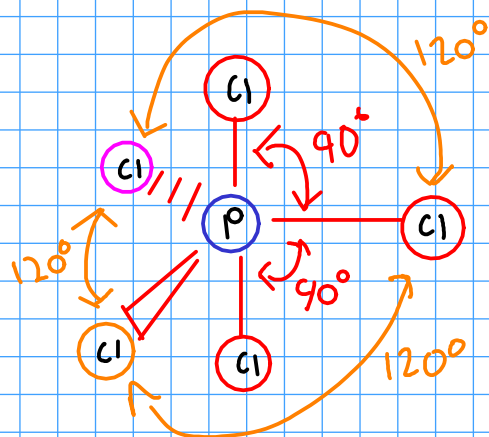


SHAPES OF EXPANDED VALENCE MOLECULES

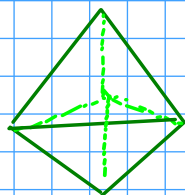


There are five atoms bonded to the central phosphorus atom, and they will attempt to get as far apart as possible from one another!



The top and bottom atoms are 90 degrees apart from the atoms around the center.

The atoms around the center are 120 degrees apart from each other.

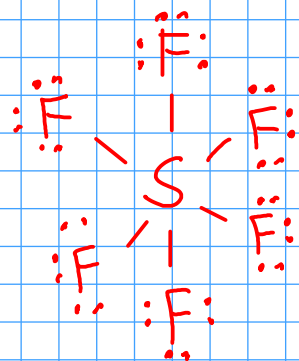


There are actually two DIFFERENT bond angles in this structure. It's called **TRIGONAL BIPYRAMIDAL**.

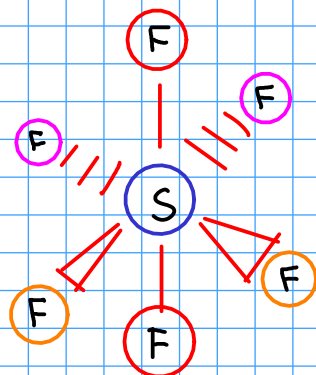
There are several derivatives of the trigonal bipyramidal shape (like the tetrahedral shape) - depending on how many things around the central atom are atoms!



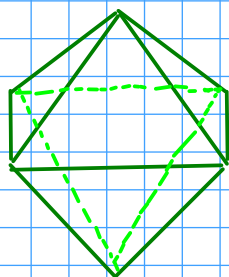
$$\begin{array}{r} \text{S: } 6 \\ \text{F: } 7 \times 6 \\ \hline 48 \end{array}$$



There are six atoms bonded to the central sulfur atom, and they will attempt to get as far apart as possible from one another!



All bond angles in this arrangement are 90 degrees!



This shape is called OCTAHEDRAL, since it has eight sides.

Like the tetrahedral and trigonal bipyramidal arrangements, there are several derivatives of the octahedron - depending on how many of the six things around the center are atoms!

POLARITY

- When atoms share electrons, the electrons might not be EVENLY shared. Shared electrons may spend more time around one atomic nucleus than the other.
- When electrons are shared UNEVENLY, this results in a POLAR BOND.

... but how can we tell whether or not a bond will be POLAR? Use experimental data on ELECTRONEGATIVITY!

ELECTRONEGATIVITY:

- A measure of how closely to itself an atom will hold shared electrons
- A bond where there is a LARGE electronegativity difference between atoms will be either POLAR or (for very large differences) IONIC!
- A bond with little or no electronegativity difference between atoms will be NONPOLAR

ELECTRONEGATIVITY TRENDS (AGAIN!)

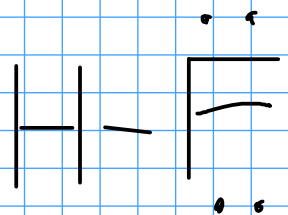
- You may look up electronegativity data in tables, but it helps to know trends!

	IA	IIA											IIIA	IVA	VA	VIA	VIIA
2	Li	Be											B	C	N	O	F
3	Na	Mg	IIIB	IVB	VB	VIB	VIIB	VIII B		IB	IIB	Al	Si	P	S	Cl	
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I
6	Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At
7	Fr	Ra	Ac*	Rf	Db	Sg	Bh	Hs	Mt	*"inner" transition metals go here							

Notes:

- ① - FLUORINE is the most electronegative element, while FRANCIUM is the least!
- ② - All the METALS have low electronegativity, and metal/nonmetal combinations form IONIC bonds
- ③ - HYDROGEN is similar in electronegativity to CARBON, so C-H bonds are considered NONPOLAR

ELECTRONEGATIVITY EXAMPLE



2.1

4.0

Electronegativity values

Difference = 1.9

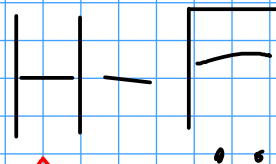
Fluorine is much more electronegative than hydrogen. This is a POLAR BOND, and the shared electrons will be held more closely to FLUORINE!

δ means "small" here

δ^+

δ^-

This end of the molecule will have a slight NEGATIVE charge, since the shared electrons are closer to FLUORINE!



This end of the molecule will have a slight POSITIVE charge, since the shared electrons are pulled away from HYDROGEN!

POLARITY OF MOLECULES

So what can a molecule's LEWIS STRUCTURE, SHAPE, and the POLARITY of its bonds tell us?

... the POLARITY of the overall molecule, which will tell us (among other things) what a given molecule will mix with or dissolve in!

POLAR MOLECULES

- Will dissolve in or dissolve other polar molecules
- Will dissolve some ionic compounds
- Will NOT easily dissolve nonpolar molecules

Example:
WATER

NONPOLAR MOLECULES

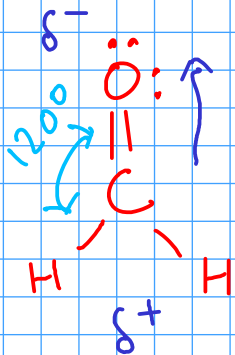
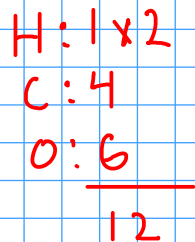
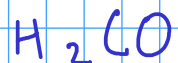
- Will dissolve in or dissolve other nonpolar molecules
- Will NOT easily dissolve nonpolar molecules or ionic compounds

Example:
OILS

For a molecule to be polar, it must ...

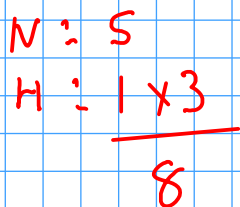
- ① Have polar bonds! (Any molecule that contains no polar bonds must be nonpolar!)
- ② Have polar bonds arranged in such a way that they don't balance each other out!
(This is why you need to know the structure and shape of the molecule)

Examples:



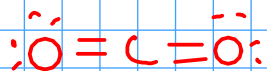
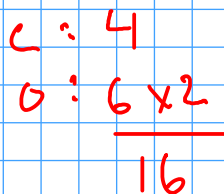
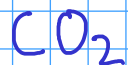
What about shape? **TRIGONAL PLANAR**. There are three things (=O, 2 -H) around the central carbon, so they will spread out as far as possible - 120 degrees.

Polarity? The C=O bond is a polar bond, and it is not "canceled" out by other bonds. The molecule is **POLAR**.



Shape? There are **FOUR** things around the central nitrogen atom - forcing the bond angles to be 109.5, or tetrahedral. **BUT**, only three of the things are atoms, and we describe shape based on **ATOMS**. We call this one **PYRAMIDAL**.

Polarity? N-H bonds are polar, and they're arranged so that the "top" of the pyramid (N) will be slightly negative, while the "bottom" H atoms will be slightly positive. So the overall molecule is **POLAR**.



Shape? Only two things (=O) around the carbon center, and they will spread out as far as possible. **LINEAR!**

Polarity? C=O bonds should be polar, but they are arranged so that they will cancel each other out. This molecule is **NONPOLAR**.

EXAMPLES

Water, H_2O

H: 2×1

O: 6

8



H

or ...



Shape? Bent! (Oxygen has four "things" around it, making it tetrahedral. The overall shape, though, depends on the ATOMS. So, BENT.)

Polarity? POLAR. The oxygen pulls electrons towards itself, making the oxygen side of the molecule slightly negative, and the hydrogen side slightly positive.

methane, CH_4

C: 4

H: 4×1

8

H

|



|

H

Shape? TETRAHEDRAL. Four atoms surround the carbon center!

Polarity? NONPOLAR. This molecule is symmetrical, but it doesn't matter since the C-H is nonpolar anyway.

CH_2F_2

C: 4

H: $2 \times 1 = 2$

F: $2 \times 7 = 14$

20

$\cdot\cdot$
 $\cdot\cdot$
 $\text{:}\ddot{\text{F}}\text{:}$

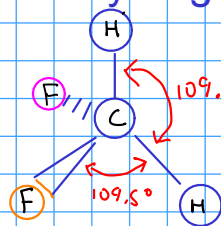


|

$\cdot\cdot$
 $\cdot\cdot$
 $\text{:}\ddot{\text{F}}\text{:}$

Shape? TETRAHEDRAL like methane.

Polarity? POLAR. In 3D, we see that the fluorines are on one side of the molecule, while the hydrogens are on the other.

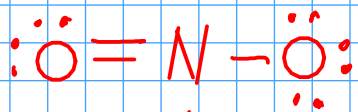


It's easier to see these "sides" in the 3D view!

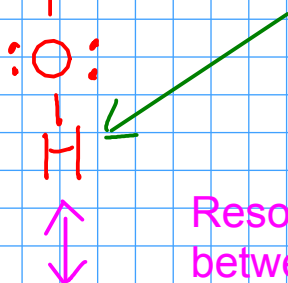


$$\begin{array}{l} \text{H: } 1 \\ \text{N: } 5 \\ \text{O: } 6 \times 3 \\ \hline 24 \end{array}$$

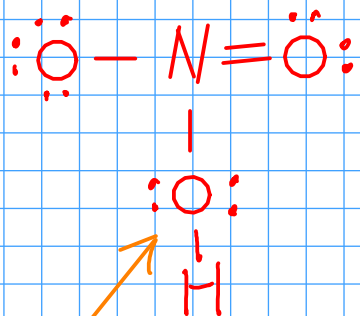
Start drawing skeleton by recognizing that this compound is an OXYACID hydrogen attached to a polyatomic ion.



In an OXYACID, the acidic hydrogen atoms are always attached to an OXYGEN atom.



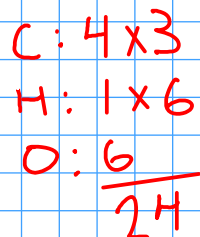
Resonance structures. The "double bond" electrons are really shared between all three atoms (O-N-O)



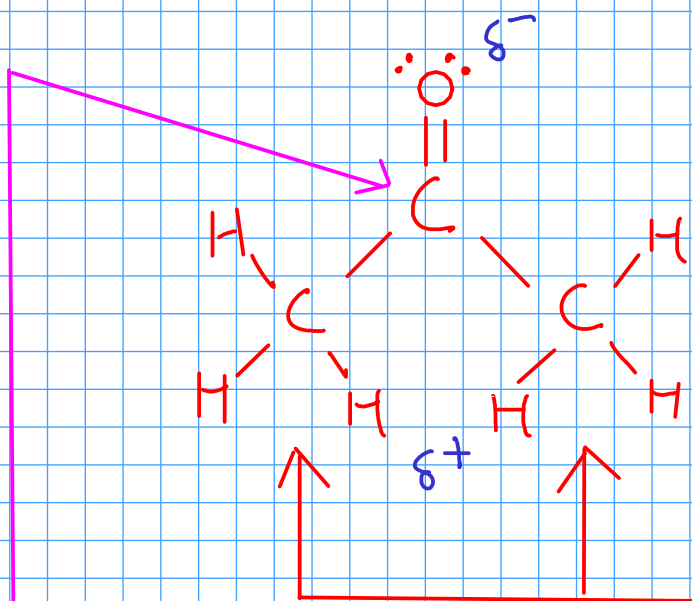
Shape? Since this molecule has two centers, give the shape around each center! Around NITROGEN, the shape is TRIGONAL PLANAR (3 things around N). Around the bottom oxygen, there are four things but only two atoms: BENT

Polarity? We expect electrons to be pulled away from H, and that the H end would end up slightly positive. POLAR.

In water, the bottom oxygen atom is able to TAKE the electrons it is sharing with H, forming IONS! (H⁺ and nitrate)!



The formula provides a clue to the skeletal structure of the molecule. There are three carbon centers in this molecule!



Shape? we need to describe the shape of the molecule around each of the carbon centers!

This carbon center is TRIGONAL PLANAR. It is surrounded by THREE other atoms and no lone pairs.

These two carbon centers are TETRAHEDRAL, since they are surrounded by four other atoms and no lone pairs.

Polarity? The C=O bond is polar, and electrons are pulled towards the oxygen "side" of the molecule. Experimentally, we observe that water (another polar molecule) and acetone mix very well with each other,