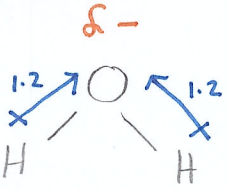
Polar Bonds vs. Polar Molecules

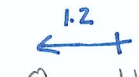
- We already learned *covalent bonds* can be polar or nonpolar based on the electronegativity of the atoms in the molecule
- We now need to look at all the individual covalent bonds in a molecule to determine if the *entire molecule* will be polar or not
- To determine if a *molecule* is polar or nonpolar follow these steps
  1. Draw the VSEPR shape of the molecule
  2. Use the electronegativities of the atoms in the molecule to determine if any bond dipoles exist. Draw the bond dipole arrows onto the VSEPR drawing
  3. "Add" up the bond dipole arrows to see if they all cancel out or not to determine if the entire molecule is *polar* or *nonpolar*.
     - If the bond dipoles arrows generally point in the same direction, the entire molecule has a side that is overall slightly positive or negative and is called a **polar molecule**
     - If the bond dipoles arrows point in opposite directions and are equal in magnitude/strength, the molecule is called **nonpolar**. In order for polar bonds to cancel each other out and result in a nonpolar molecule, the molecule needs to be symmetrical.

- EXAMPLE: Show that H_2O is a polar molecule.

H = 1e⁻ x2
O = 6e⁻
= 8e⁻



bent

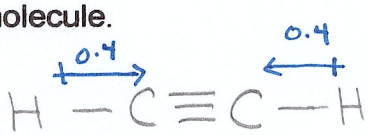


ΔEN = 3.4 − 2.2
ΔEN = 1.2

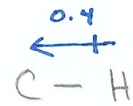
∴ polar

- EXAMPLE: Show that C_2H_2 is a nonpolar molecule.

C = 4e⁻ x2
H = 1e⁻ x2
= 10e⁻



linear



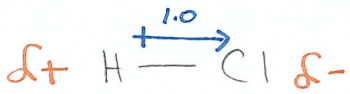
ΔEN = 2.6 − 2.2
ΔEN = 0.4

∴ non polar

- **EXAMPLES**: Draw the Lewis structure and the VSEPR shape for each molecule and then determine if the following molecules are polar or nonpolar.

1. **HCl** = polar

H = 1e⁻
Cl = 7e⁻
= 8e⁻



linear

ΔEN = 3.2 - 2.2
ΔEN = 1.0

4. **N_2** = non polar

N = 5e⁻ x 2
= 10e⁻

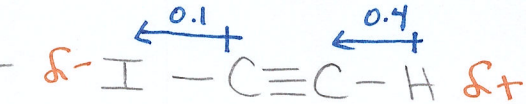
N ≡ N

linear

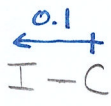
ΔEN = 3.0 - 3.0
ΔEN = 0
∴ no bond dipole

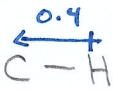
2. **C_2HI** = polar

C = 4e⁻ x 2
H = 1e⁻
I = 7e⁻
= 16e⁻



linear



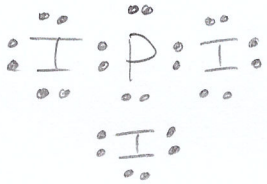


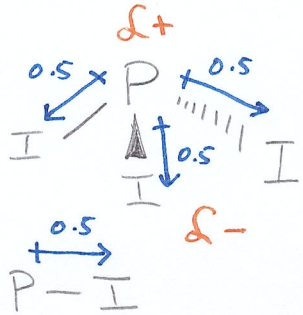
ΔEN = 2.7 - 2.6
ΔEN = 0.1

ΔEN = 2.6 - 2.2
ΔEN = 0.4

5. **PI_3** = polar

P = 5e⁻
I = 7e⁻ x 3
= 26e⁻



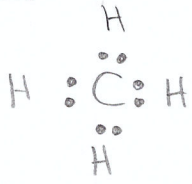


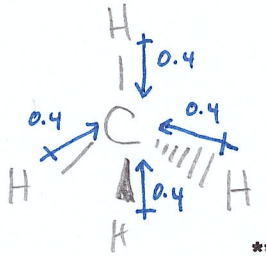
trigonal pyramidal

ΔEN = 2.7 - 2.2
ΔEN = 0.5

3. **CH_4** = non polar

C = 4e⁻
H = 1e⁻ x 4
= 8e⁻

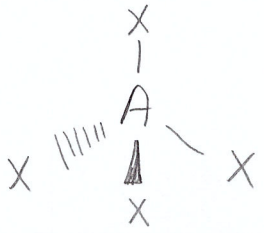
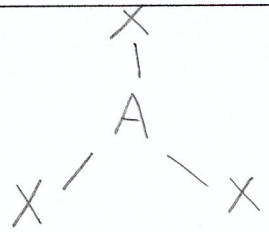
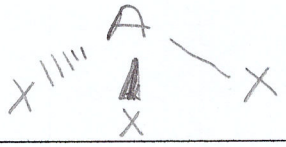




tetrahedral

*****Now Try Practice Problems*****

- Summary Chart on Polar vs. Nonpolar Molecules

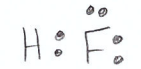
Shape	VSEPR Diagram	Polar (P) or Non-polar (NP)
Tetrahedral		NP if all atoms same P if atoms attached to central atom are different
Trigonal planar		NP if all atoms attached to central atom are the same P if atoms attached to central atom are different
Pyramidal		Always P
Bent		Always P
Linear		NP if symmetrical P if non symmetrical

Practice Problems

Draw the VSERP shape for each molecule and determine if the molecule will be polar or nonpolar.

1. HF = polar

H = 1e⁻
F = 7e⁻
= 8e⁻



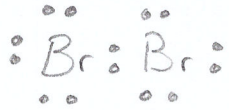
δ+ H — F δ−

linear

ΔEN = 4.0 - 2.2
ΔEN = 1.8

2. Br_2 = non polar

Br = 7e⁻ x 2
= 14e⁻



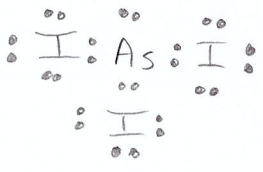
Br — Br

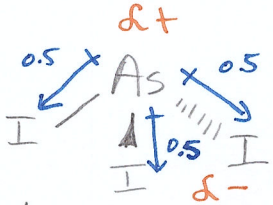
linear

ΔEN = 3.0 - 3.0
ΔEN = 0
∴ no bond dipole

3. AsI_3 = polar

As = 5e⁻
I = 7e⁻ x 3
= 26e⁻



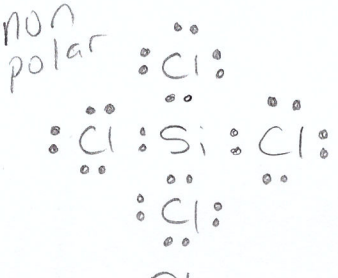


trigional pyramidal

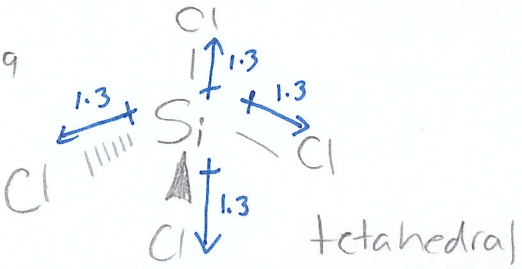
ΔEN = 2.7 - 2.2
ΔEN = 0.5

4. $SiCl_4$ = non polar

Si = 4e⁻
Cl = 7e⁻ x 4
= 32e⁻



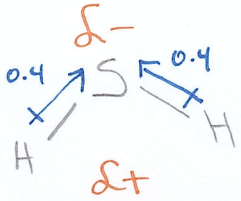
ΔEN = 3.2 - 1.9
ΔEN = 1.3



tetahedral

5. H_2S = polar

H = 1e⁻ x 2
S = 6e⁻
= 8e⁻

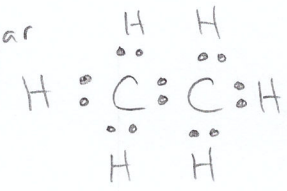


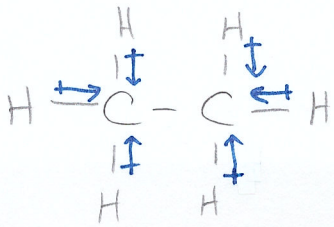
bent

ΔEN = 2.6 - 2.2
ΔEN = 0.4

6. C_2H_6 = non polar

C = 4e⁻ x 2
H = 1e⁻ x 6
= 14e⁻

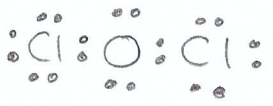


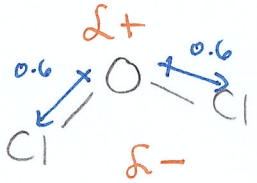


ΔEN = 2.6 - 2.2
ΔEN = 0.4

7. Cl_2O = polar

Cl = 7e⁻ x 2
O = 6e⁻
= 20e⁻



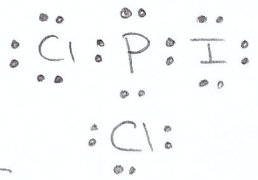


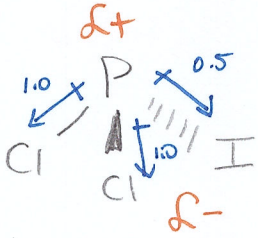
bent

ΔEN = 3.2 − 2.6
ΔEN = 0.6

8. $PICl_2$ = polar

P = 5e⁻
I = 7e⁻
Cl = 7e⁻ x 2
= 26e⁻





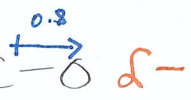
trigonal pyramidal

P − I
ΔEN = 2.7 − 2.2
ΔEN = 0.5

P − Cl
ΔEN = 3.2 − 2.2
ΔEN = 1.0

9. COS = polar

C = 4e⁻
O = 6e⁻
S = 6e⁻
= 16e⁻



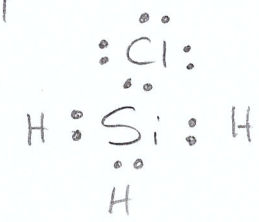
linear

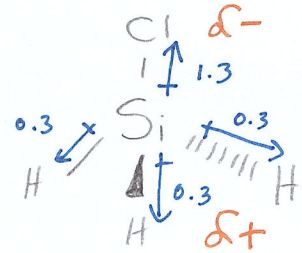
S − C
ΔEN = 2.6 − 2.6
ΔEN = 0

C − O
ΔEN = 3.4 − 2.6
ΔEN = 0.8

10. SiH_3Cl = polar

Si = 4e⁻
H = 1e⁻ x 3
Cl = 7e⁻
= 14e⁻





tetrahedral

Si − Cl
ΔEN = 3.2 − 1.9
ΔEN = 1.3

Si − H
ΔEN = 2.2 − 1.9
ΔEN = 0.3

11. H_2S_2 = non polar

H = 1e⁻ x 2
S = 6e⁻ x 2
= 14e⁻

linear

ΔEN = 2.6 − 2.2
ΔEN = 0.4