Polar Molecules

Unit: Intermolecular Forces

MA Curriculum Frameworks (2016): HS-PS1-2, HS-PS1-3

Mastery Objective(s): (Students will be able to…)

- Draw polarity arrows indicating polarity of a molecule.

Success Criteria:

- Arrow is in the correct direction and points from the $\delta+$ atom to the $\delta-$ atom.

Tier 2 Vocabulary: polar

Language Objectives:

- Explain how electrons are distributed unevenly in polar molecules.

Notes:

polar bond: a covalent bond that has opposite partial charges on each end (one end partially positive and one end partially negative), because of unequal sharing of electrons.

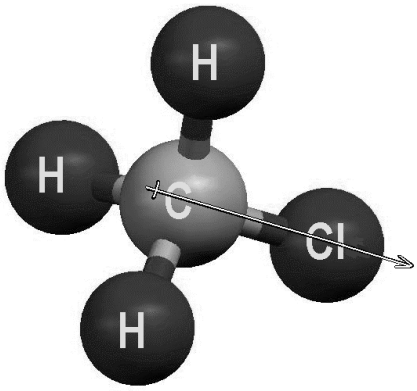
polar molecule: a molecule that can be oriented so that it has opposite charges on opposite sides.

In order to be polar, a molecule must have both:

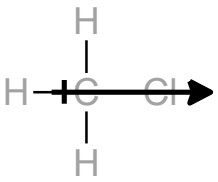
1. one or more polar bonds
2. an "axis of asymmetry," meaning a way to orient the molecule so that there is more partial positive charge on one side (relative to the central atom), and more partial negative charge on the opposite side.

Use this space for summary and/or additional notes:

For example, the CH_3Cl molecule is polar, because the C-Cl bond is polar ($\Delta\chi = 0.61$), and because you can view the central atom (carbon) so that the negative charge (towards chlorine) is on one side:



Notice the polarity arrow  running from C to Cl in the molecule. The arrow shows the direction of polarization (pointing towards the more electronegative atom), and the "+" at the tail of the arrow indicates the end that has the partial positive ($\delta+$) charge. Polarity arrows are often used with Lewis structures:



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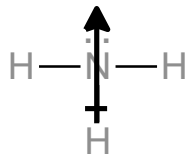
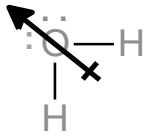
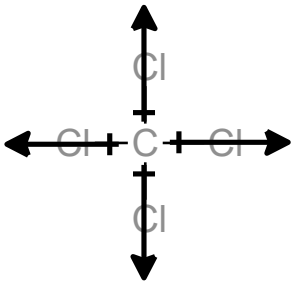
Because lone pairs of electrons change the symmetry of the molecule, trigonal pyramidal and bent molecules that contain polar bonds will usually be polar molecules. For example, NH_3 is polarized towards the nitrogen atom:



and water is polarized towards the oxygen atom:



However, if a molecule has multiple polar bonds that are pulling equally in opposite directions, then the forces cancel out and the molecule is not polar. An example of a *nonpolar molecule* that does have polar bonds is CCl_4.



Each of the C-Cl bonds is polar, but the forces all cancel out, so there is no net force in any direction.

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Dipole Moment

The polarity of a molecule can be expressed quantitatively as its dipole moment.

moment: in physics, the degree to which mass is spread out from the center of (potential) rotation. For example, an object's moment of inertia measures how much the object resists forces that would cause it to rotate.

dipole moment: a measure of how strongly a dipole will react to an external field. The dipole moment is expressed as the moment of inertia caused by a pair of charges (+*q* and −*q*) separated by a distance *d.*

The dipole moment (μ) is expressed by the formula:

$$\mu = qd$$

The unit for dipole moment is the debye (D).

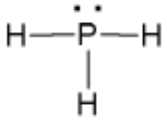
Stronger charges (or partial charges) and/or greater distance between those charges will result in a larger dipole moment (and therefore a more polar molecule).

Use this space for summary and/or additional notes:

Homework Problems

For each of the following Lewis structures:

- Draw polarity arrows next to each polar bond.
- If the molecule is polar, draw a large polarity arrow for the molecule.
- If the molecule is non-polar, write “non-polar” next to it.

1. 

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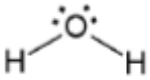
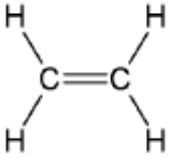
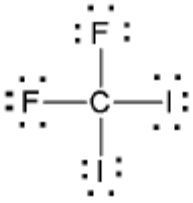
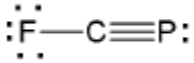
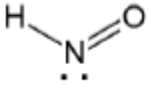
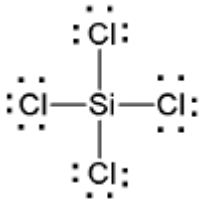
3. 

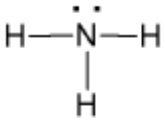
4. 

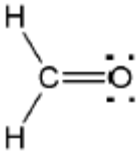
5. 

6. 

7. 

8. 

9. 

10. 

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