

Polar and Nonpolar Covalent Bonds

- In some molecular compounds, the bonding electrons are shared equally between the atoms.

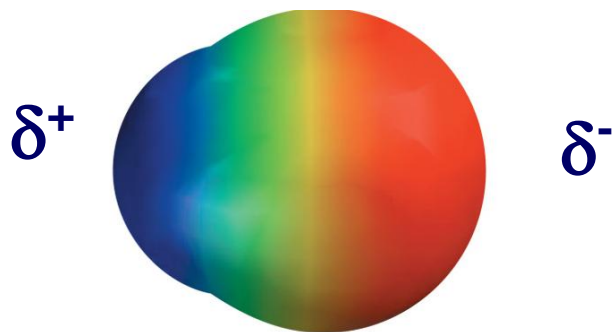


F₂

- **Nonpolar covalent bond:**
 - bonding electrons are shared equally
- In a nonpolar covalent bond the electron density is spread evenly (or essentially evenly) between the two atoms in the bond.

Polar and Nonpolar Covalent Bonds

- In many molecular compounds, however, one atom attracts the bonding electrons more strongly than the other.



HF

Fluorine attracts electrons more strongly than hydrogen.

The fluorine end of the molecule has higher electron density than the hydrogen end.

The H - F bond is a **polar covalent bond**.

Polar and Nonpolar Covalent Bonds

- **Polar covalent bond:**
 - A chemical bond in which the electrons are not shared equally due to differences in the **electronegativity** of the atoms

- **Electronegativity:**
 - The ability of an atom in a molecule to attract electrons towards itself

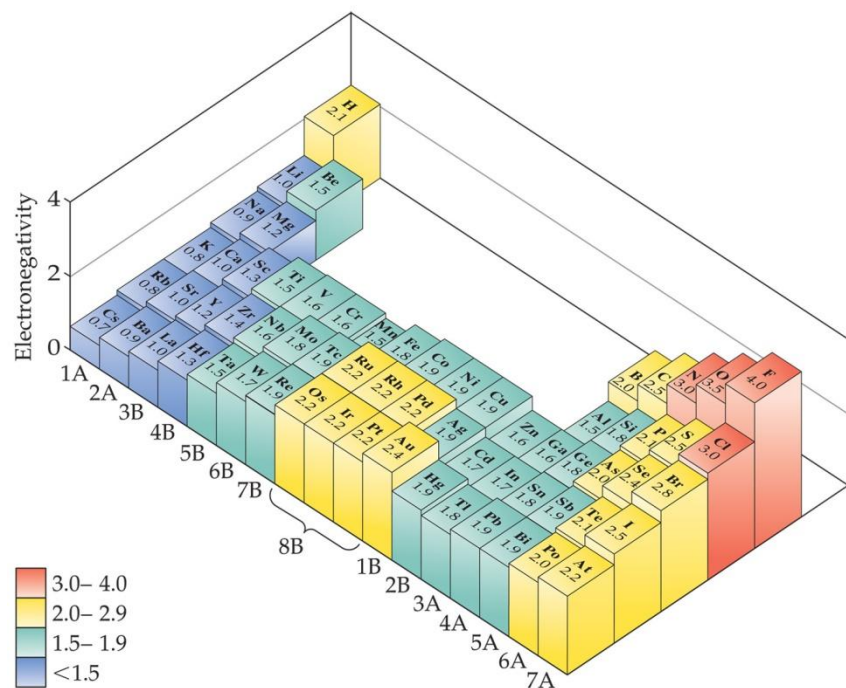
 - **Range: 0.7 (Cs) – 4.0 (F)**

Polar and Nonpolar Covalent Bonds

- As electronegativity increases, the attraction of the atom for electrons increases.
- The four most electronegative elements are:
 - F (4.0)
 - O (3.5)
 - N (3.0)
 - Cl (3.0)

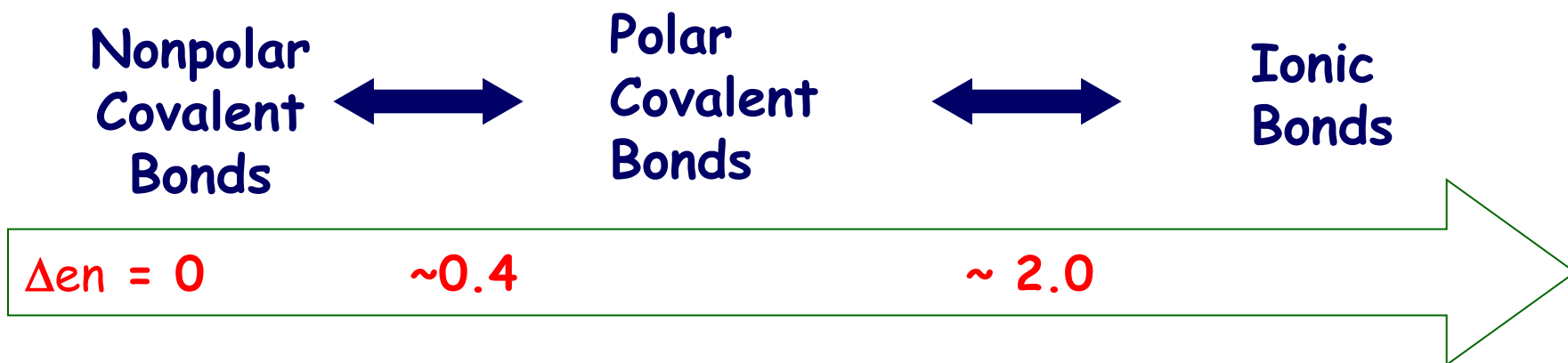
Polar and Nonpolar Covalent Bonds

- Electronegativity increases from left to right within a period.
- Electronegativity increases from the bottom to the top of a group.



Polar and Nonpolar Covalent Bonds

- Chemical bonds exist along a continuum:



- The greater the difference in electronegativity between two atoms, the more polar their bond is.



$\Delta en = 0$

nonpolar covalent



$\Delta en = 1.9$

polar covalent



$\Delta en = 3.0$

ionic

Polar and Nonpolar Covalent Bonds

- Polar covalent bonds

- typically $\Delta en = \sim 0.4 - 2.0$

- Common polar covalent bonds to know:



- Nonpolar covalent bonds

- typically $\Delta en < \sim 0.4$

- Common nonpolar covalent bonds to know:



Polar and Nonpolar Covalent Bonds

Example: Classify each of the following bonds as an ionic, polar covalent, or nonpolar covalent bond.

Br - Br

O - H

C - H

H - Br

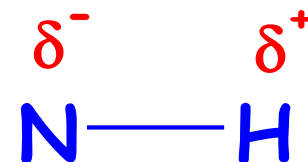
Al - Cl

Polar and Nonpolar Covalent Bonds

- The polarity of a covalent bond is measured using its dipole moment.
 - Large dipole moment = more polar
 - Small dipole moment = more nonpolar
- The distribution of electron density in a bond can be depicted using:
 - Partial charges
 - δ^+ and δ^-
 - Direction of dipole moment



Polar and Nonpolar Covalent Bonds

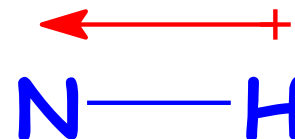


□ Partial charges:

- Place the partial negative charge (δ^-) over (or under) the more electronegative element
- Place the partial positive charge (δ^+) over (or under) the less electronegative element

□ Direction of dipole:

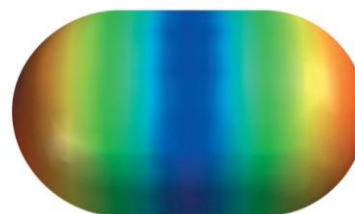
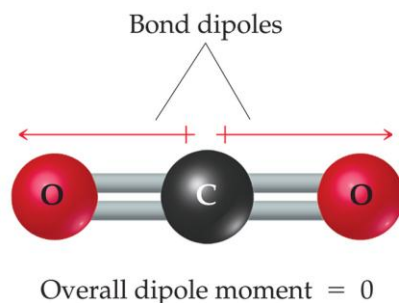
- Place the positive end of the arrow over (or under) the less electronegative element.
- Point the arrow in the direction of the more electronegative element



Polar and Nonpolar Molecules

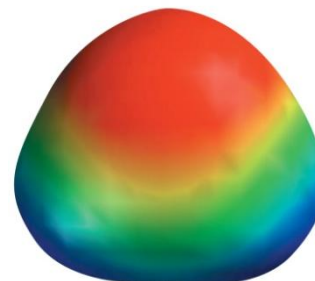
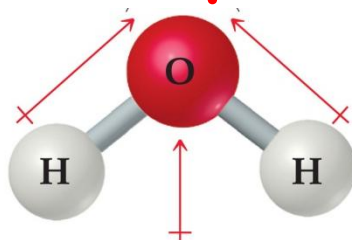
- Carbon dioxide contains 2 polar covalent bonds.

- It is a **nonpolar molecule**, however.



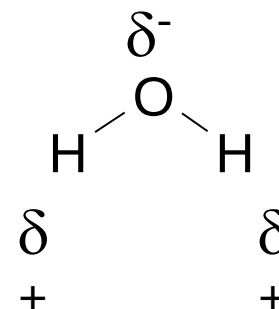
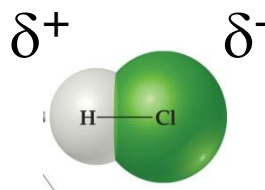
- Water also contains 2 polar covalent bonds.

- It is a **polar molecule**!



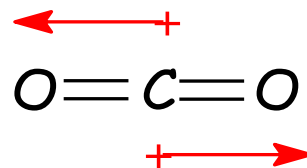
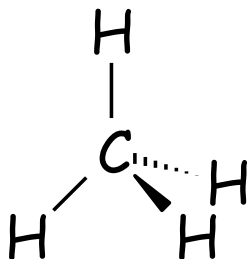
Polar and Nonpolar Molecules

- Polar molecules
 - Electron density is distributed asymmetrically throughout the molecule
 - Contain a "negative" end and a "positive" end
 - A molecule is a polar molecule if:
 - It contains exactly 1 polar covalent bond.
- OR
- Two or more polar covalent bonds are arranged asymmetrically within the molecule.
- HCl
 - H₂O



Polar and Nonpolar Molecules

- **Nonpolar molecules:**
 - Electron density is distributed symmetrically within the molecule
 - A molecule will be nonpolar if:
 - It contains only nonpolar covalent bonds
- OR
- If two more more polar covalent bonds are arranged symmetrically within the molecule.



Polar and Nonpolar Molecules

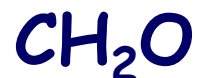
- To determine if a molecule is polar or nonpolar:
 - Draw the Lewis structure
 - Count the number of polar covalent bonds:
 - Zero polar covalent bonds
 - nonpolar molecule
 - One polar covalent bond
 - polar molecule
 - Two or more polar covalent bonds:
 - Continue to next step

Polar and Nonpolar Molecules

- If two or more polar covalent bonds are present:
 - Draw the structure in 3-dimensions
 - Draw the direction of the dipoles for each polar covalent bond
 - If the dipoles are arranged **symmetrically** (i.e. offset each other)
 - **Nonpolar molecule**
 - If the dipoles are arranged **asymmetrically**
 - **Polar molecule**

Polar and Nonpolar Molecules

Example: Identify each of the following compounds as either a polar molecule or a nonpolar molecule.



Household Chemicals

- You are responsible for knowing the names and formulas for the following common household chemicals:

- Water (H_2O)

- Ammonia (NH_3)

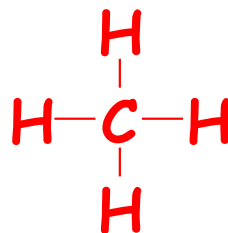
- Hydrogen peroxide

- H_2O_2

- Natural gas

- Methane

- CH_4

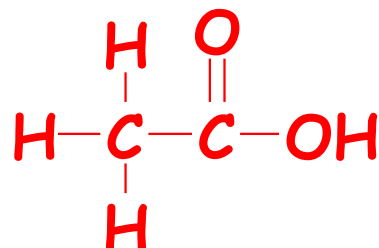


Household Chemicals

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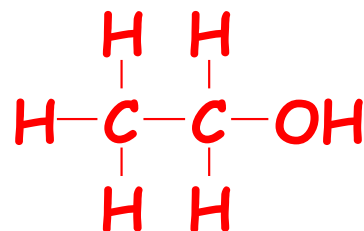
- **Vinegar**

- **Acetic acid**
- **$\text{HC}_2\text{H}_3\text{O}_2$**



- **Drinking alcohol**

- **Ethanol**
- **$\text{C}_2\text{H}_5\text{OH}$**

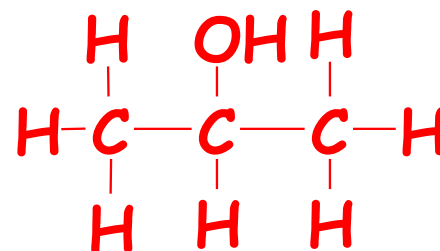


Household Chemicals

- You are responsible for knowing the names and formulas for the following common household chemicals:

- Rubbing alcohol

- Isopropyl alcohol



- Nail polish remover

- Acetone

