Section 10.1
Intermolecular Forces

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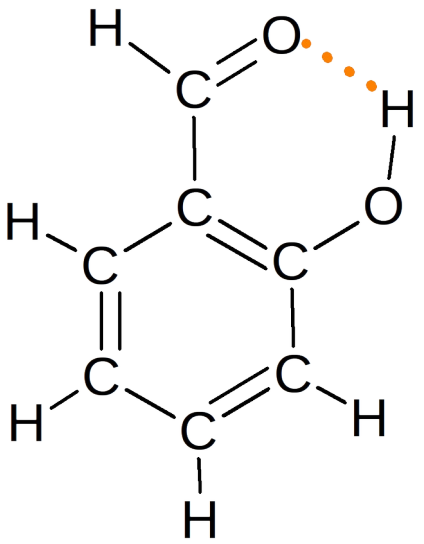
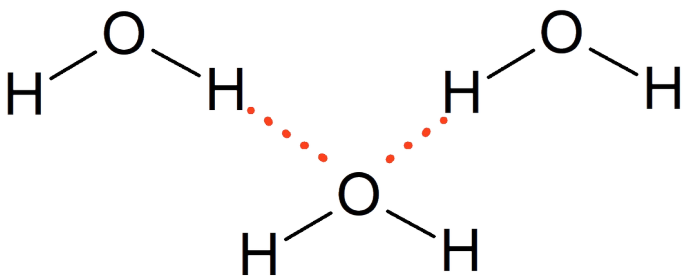
Intramolecular vs. **Inter**molecular

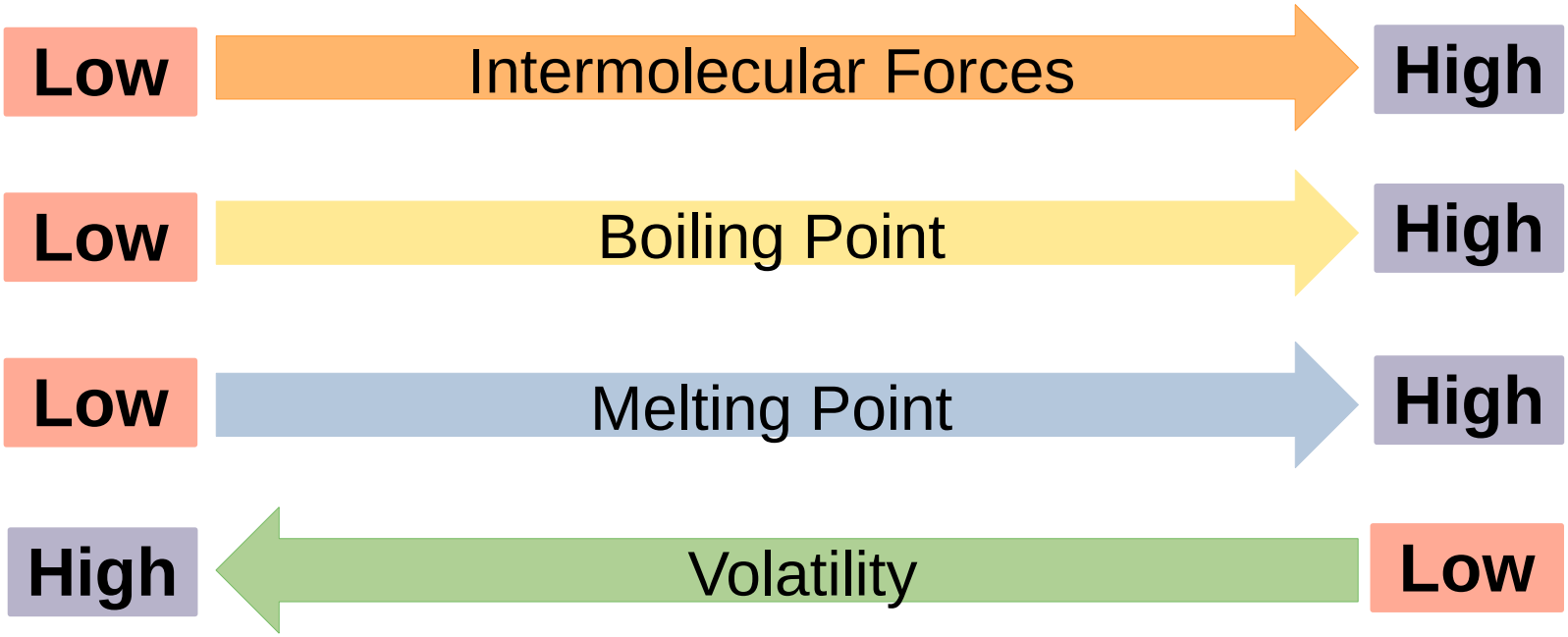
- *Intramolecular Forces* are interactions that occur within a molecule.



- *Intermolecular Forces* are interactions that occur between two or more molecules.



Effect on Bulk Properties



PHET States of Matter

Types of Intermolecular Forces

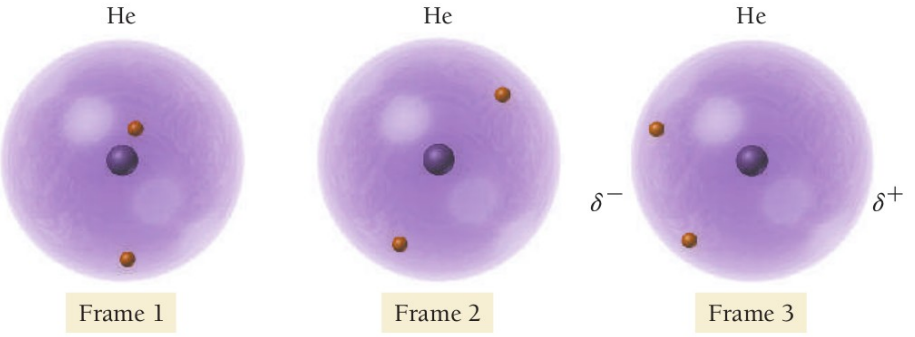
Increasing Strength

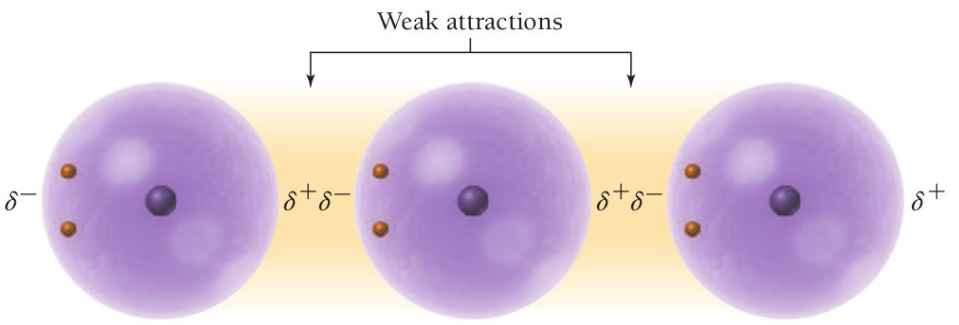
Interaction	Cause
Dispersion (Van Der Waal)	Instantaneous Dipole
Dipole-Dipole	Dipole Moments
Hydrogen Bonding	H interacting with F, O, or N.

Dispersion Forces

Instantaneous Dipoles

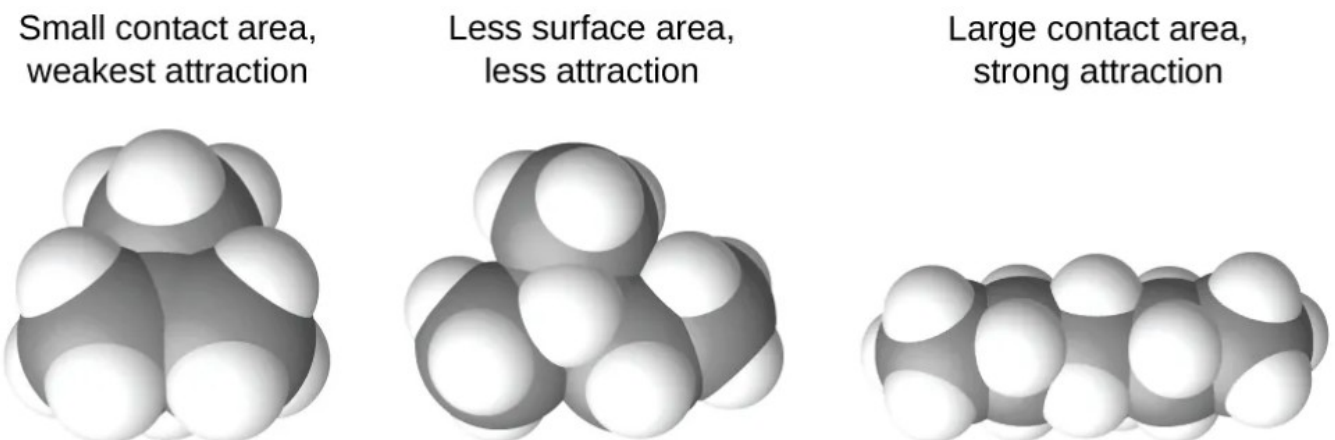
- Instantaneous Dipoles can be induced in any molecule or atom.
- This a weak and non-permanent interaction.
- The interaction becomes stronger with increased formula mass, atomic mass, and effective surface area.





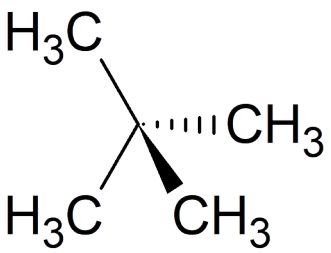
Nonpolar Organic Molecules

- Organic Molecules that only experience dispersive intermolecular interactions.
- Larger molecules have stronger interactions.
- Branching decreases dispersive interactions.



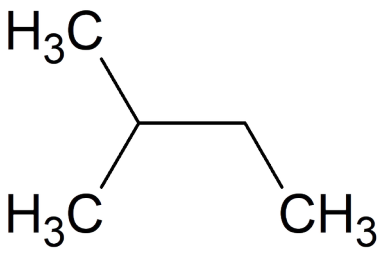
Experimental Evidence

- As predicted, the boiling point increases for less branched constitutional isomers.



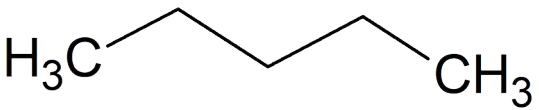
2,2-dimethylpropane

BP : 9.5 °C



2-methylbutane

BP : 27 °C

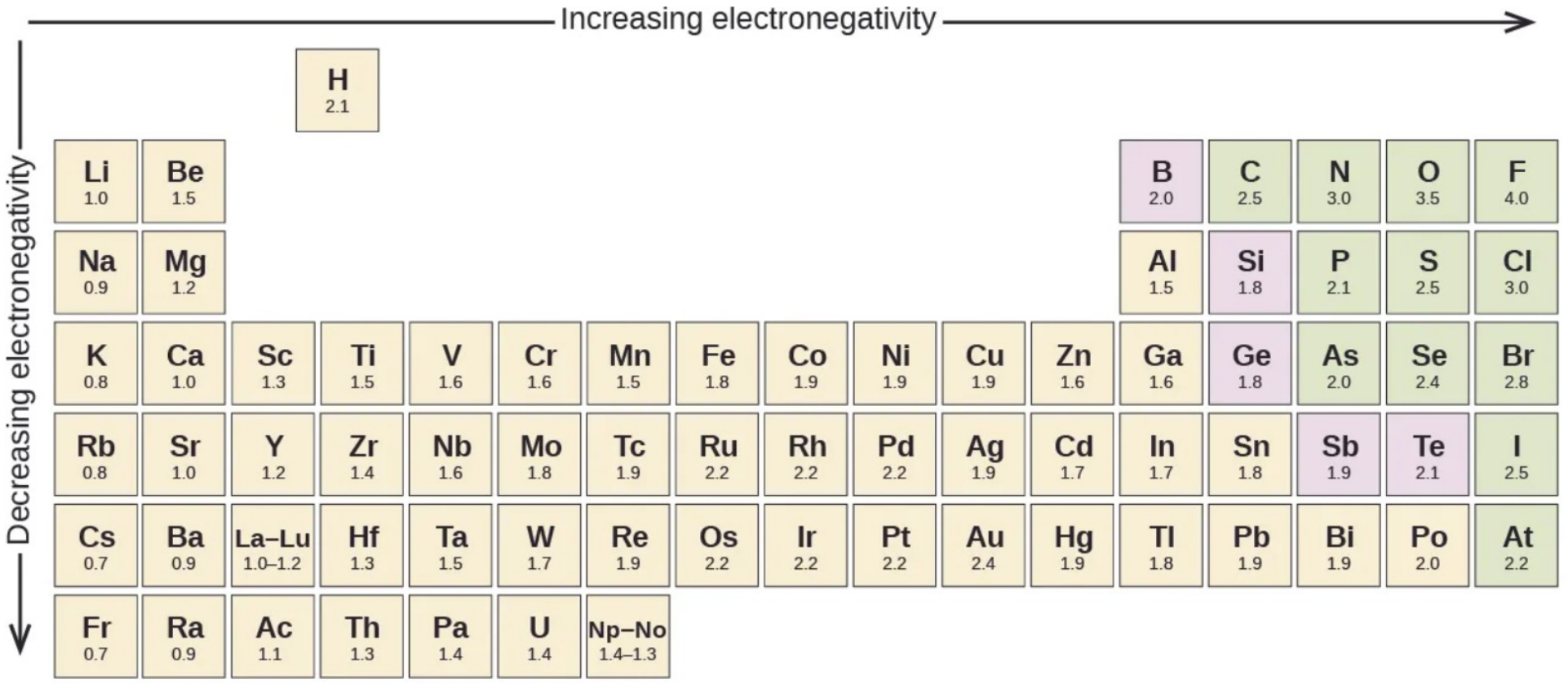


n-pentane

BP : 36 °C

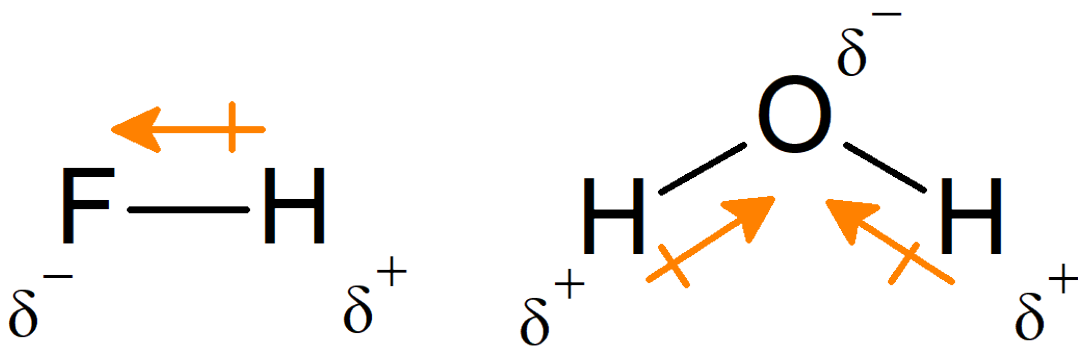
Dipole Interactions

Periodic Table of Electronegativity



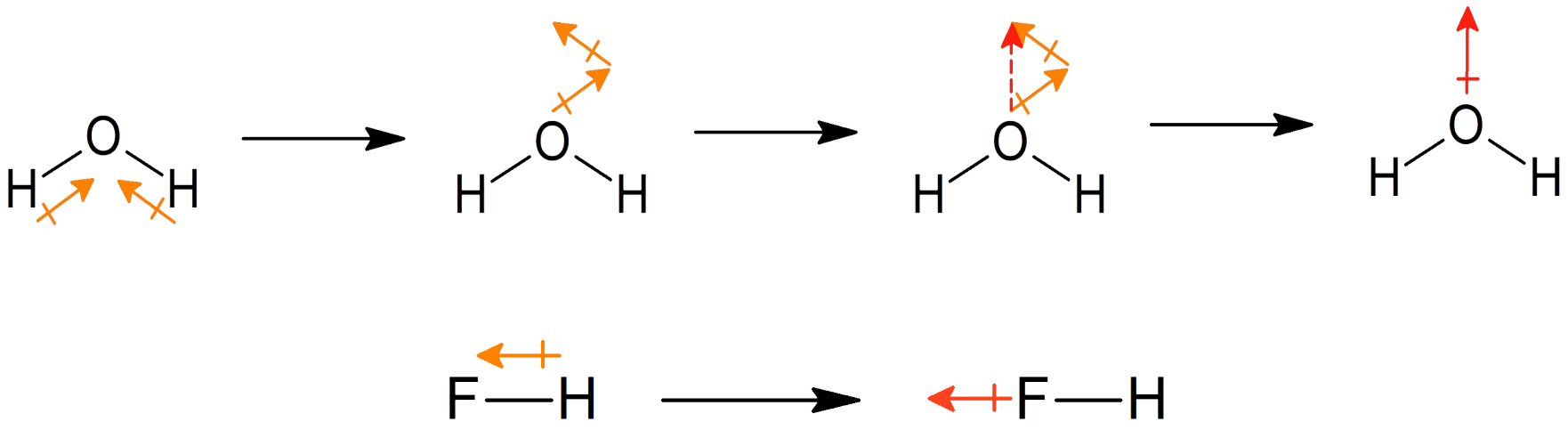
Bond Dipoles

- **Bond Dipoles** are an *intramolecular* interaction that lead to **Dipole Moments** an *intermolecular* interaction.
- They arise when two atoms with different electronegativity are bound together.



Dipole Moments

- **Dipole Moments** are found by summing a molecule's **Bond Dipole** vectors.

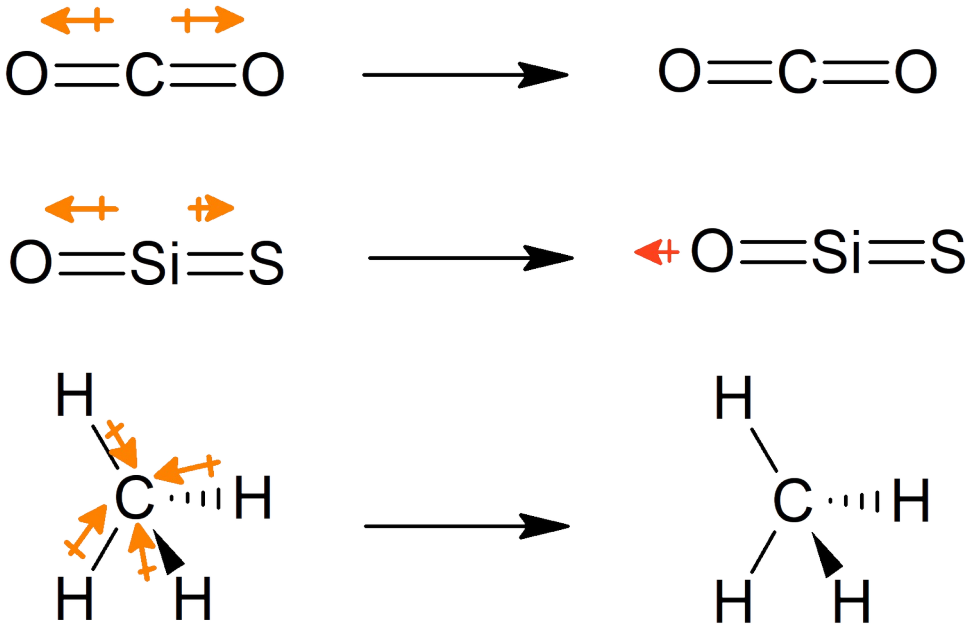


Additive Vectors

- When Bond Dipoles are facing the same direction, the result is a Dipole Moment with a large magnitude.

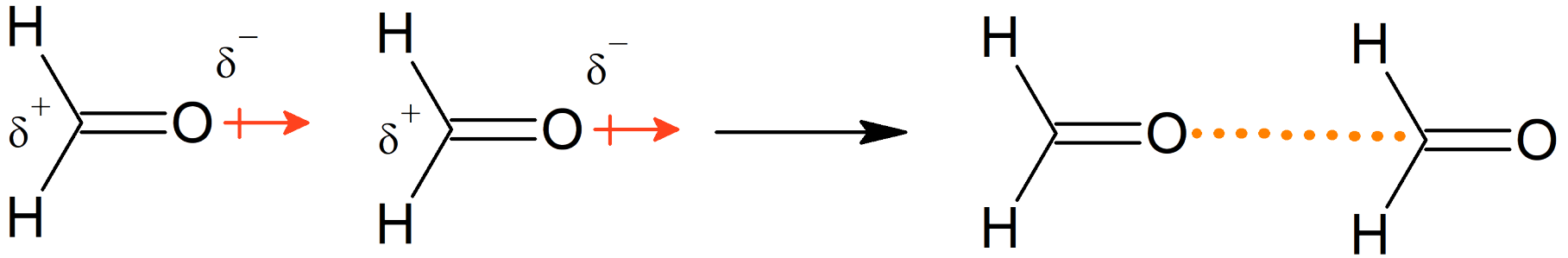
Subtracting Vectors

- When **Bond Dipoles** oppose one another the result can be a small or nonexistent **Dipole Moment**.



Polar Organic Molecules

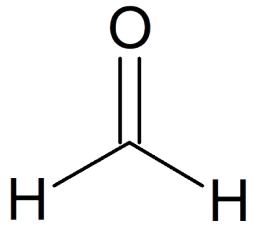
- When two molecules with dipoles come close to one another, their dipoles align leading to an interaction.



PHET Molecule Polarity

Evidence of Dipole-Dipole Interactions

- Again, we can find examples that reinforce our theory.

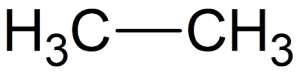


formaldehyde

Formula Mass:

30.031 g/mol

BP: -19 °C



ethane

Formula Mass:

30.07 g/mol

BP: -89 °C

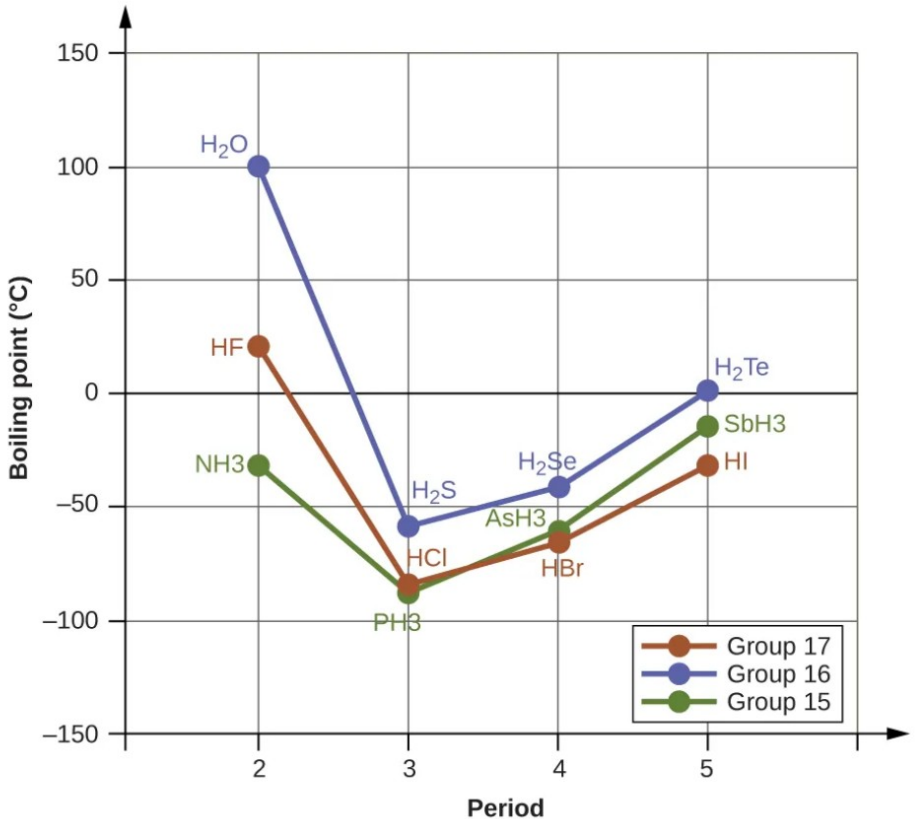
Hydrogen Bonding

Hydrogen Bonding

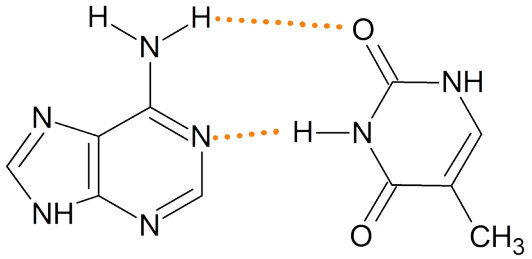
- Hydrogen Bonding is a special case of Dipole-Dipole interactions.
- When hydrogen is bound to a sufficiently electronegative atom (O, N, or F) the single electron on the atom is drawn far away from the nucleus.
- The result is *highly concentrated partial charge* leading to a stronger than normal interaction.

Evidence of Hydrogen Bonding

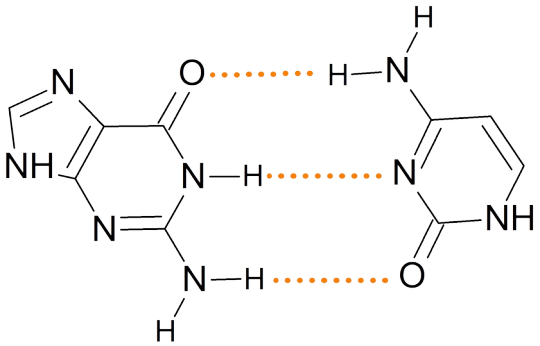
- When we analyze the boiling points of hydrides in Groups 17, 16, and 15, we see a significant break in the trend predicted by considering dispersive forces alone.



Implications in Organic Chemistry



Adenine Thymine



Guanine Cytosine

- Hydrogen Bonding plays an important role in dictating the conformation of many large organic molecules.
- It is responsible for the bonding between nucleic acid base pairs that bind together strands of DNA.

Conclusions

- All molecules and atoms are subject to dispersive forces that induce partial charge differentials leading to *instantaneous dipoles.*
- Differences in the electronegativity of atoms bound together lead to *bond dipoles*.
- Bond dipoles can sum to produce *dipole moments* depending on molecular geometry.
- Hydrogen bound to O, N, or F results in *hydrogen bonding.*
- Intermolecular forces have a significant impact on bulk properties.