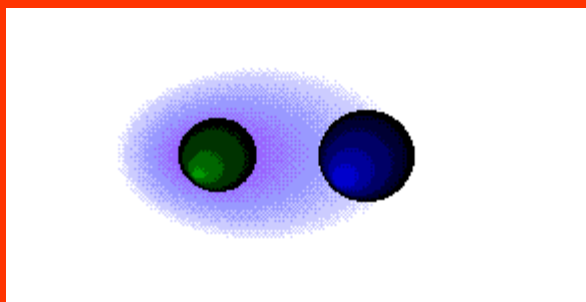


Liquids and Solids

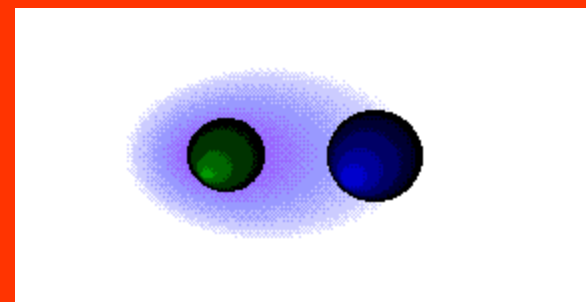
Dipole-Dipole Forces

Attraction between the positive end of one molecule and the negative end of another. Strong attractions, but not as strong as hydrogen bonding. These are only found in polar molecules.



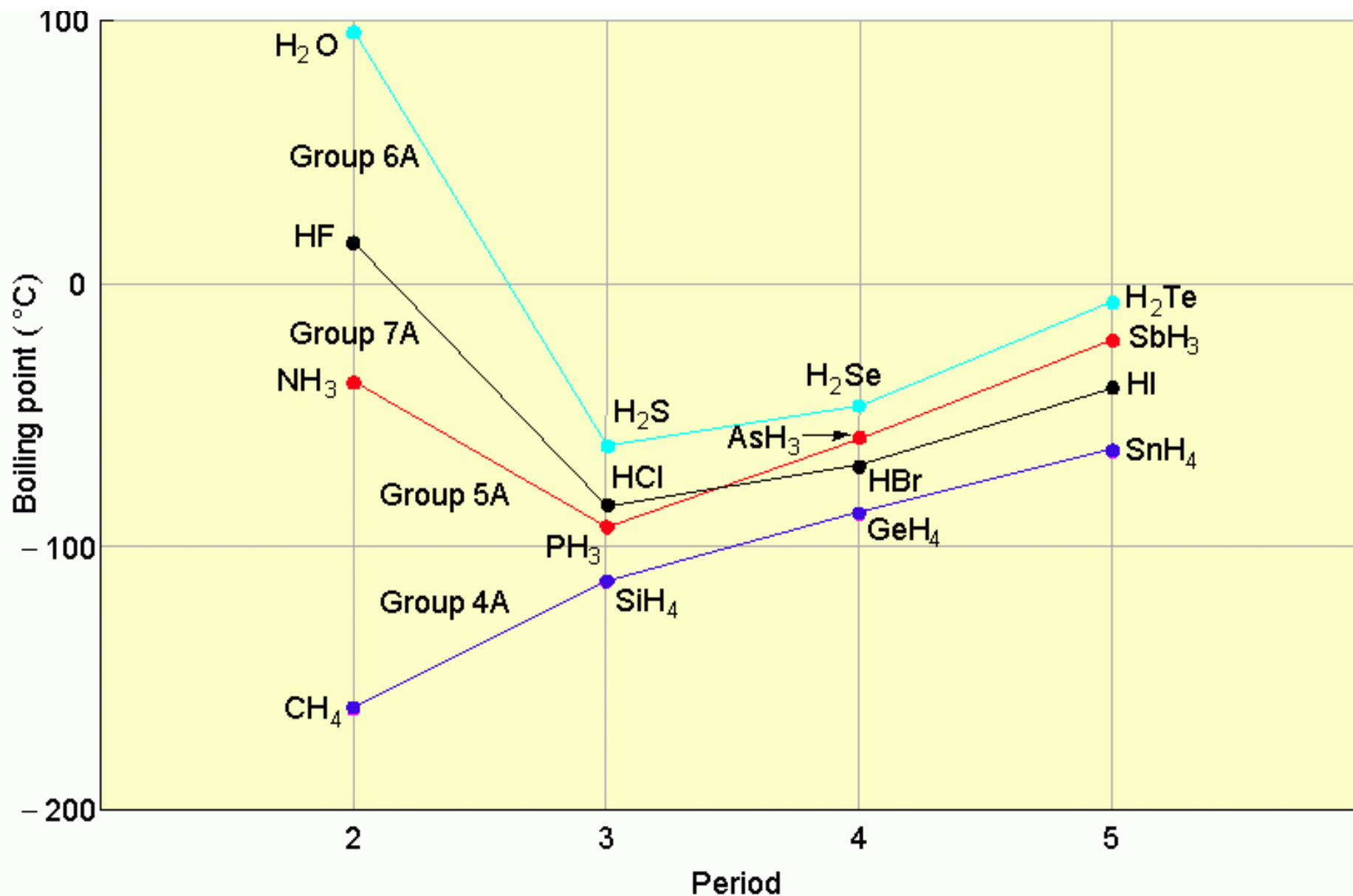
δ^- charge

δ^+ charge



δ^- charge

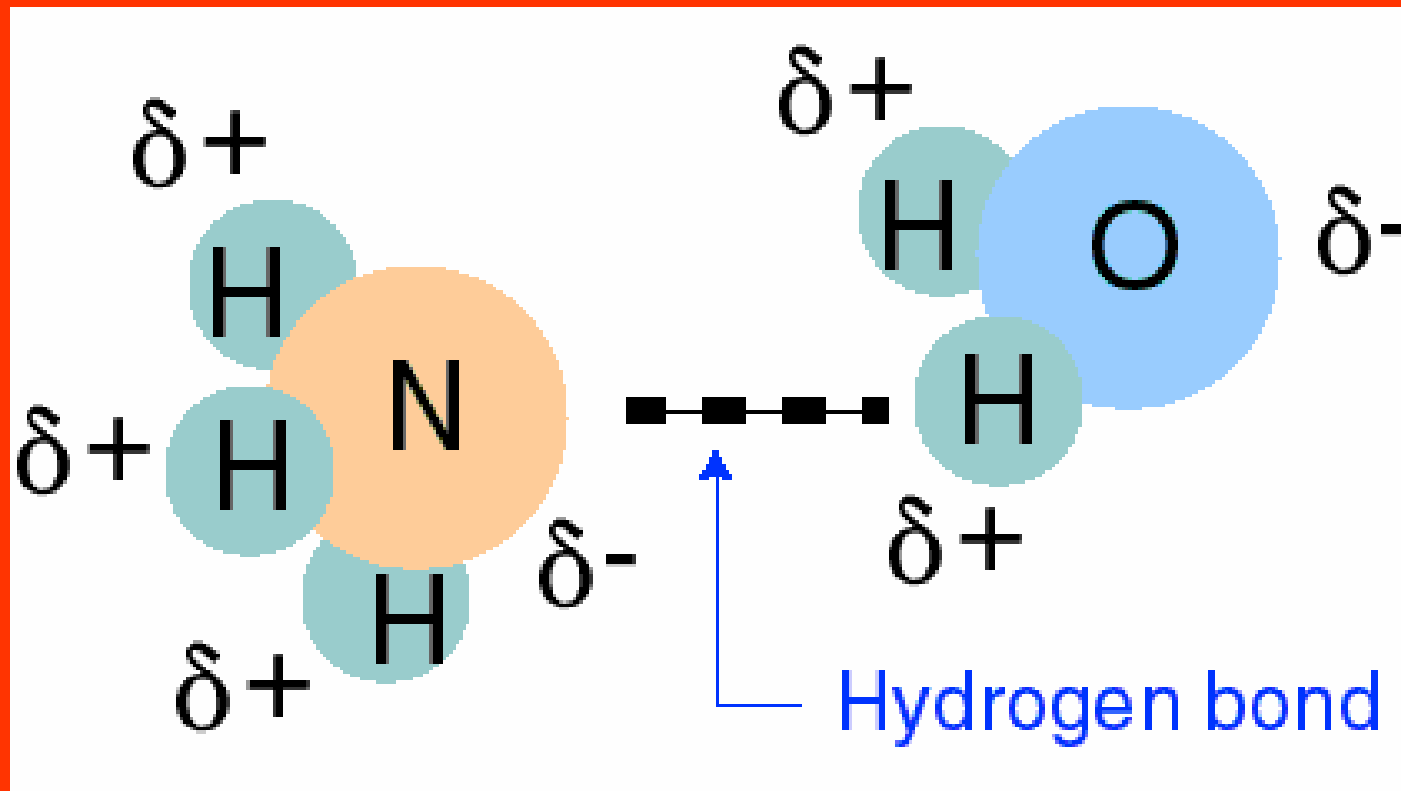
δ^+ charge



Boiling point as a measure of intermolecular attractive forces

Hydrogen Bonding

Bonding between hydrogen and more electronegative neighboring atoms such as oxygen and nitrogen



Hydrogen bonding between ammonia and water

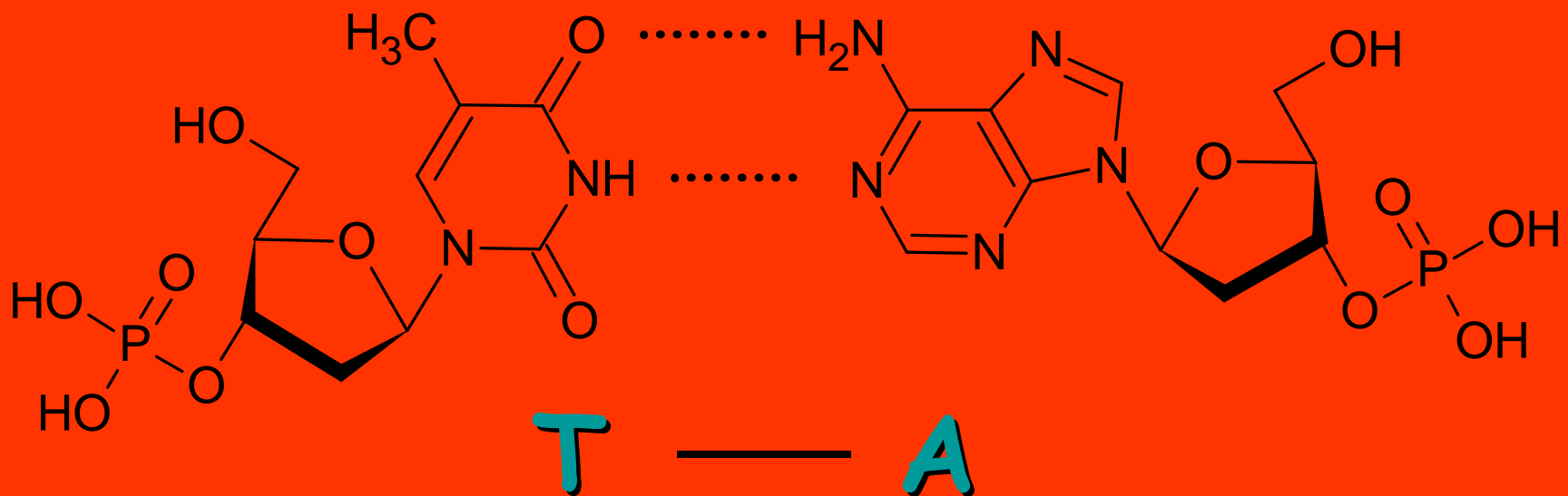
Factors making Hydrogen Bonding

Special strong dipole-dipole attraction

1. The small size of the elements F,N,O
 2. The relatively high electronegativity of them.
- This allows for the creation of strong dipole forces of attraction between the molecules. The effect of which can be seen on the boiling point of substances that contain hydrogen bonding.

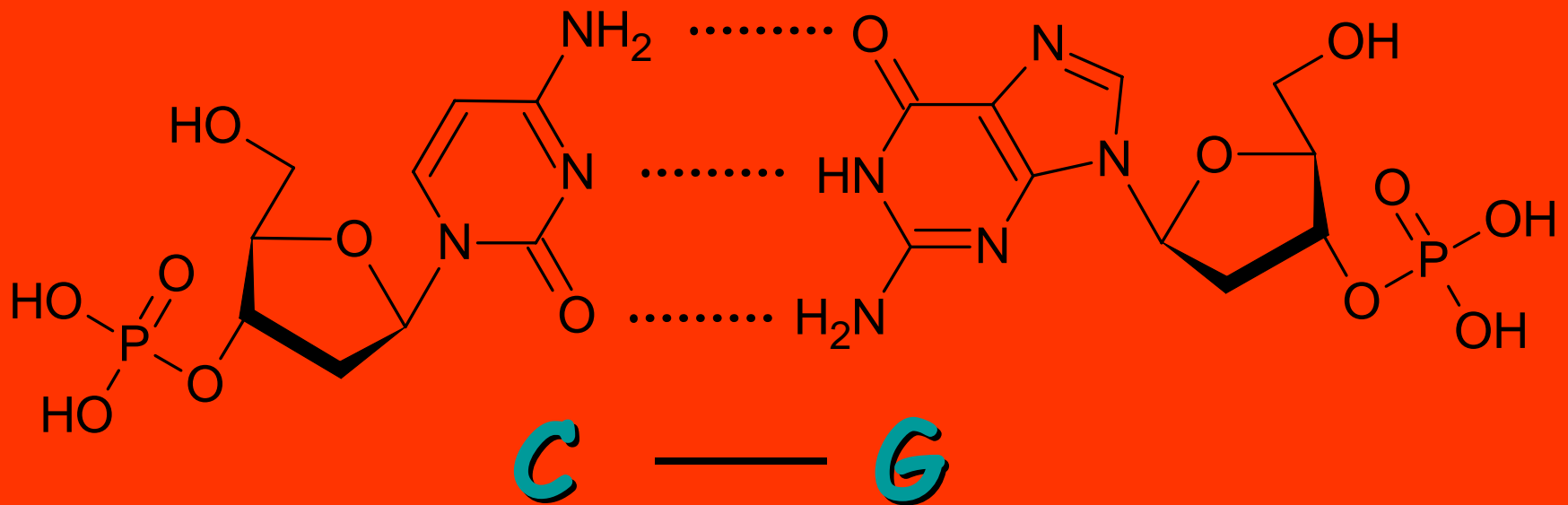
Hydrogen Bonding in DNA

thymine hydrogen bonds to adenine



Hydrogen Bonding in DNA

cytosine hydrogen bonds to guanine



London Dispersion Forces



Fritz London
1900-1954

The temporary separations of charge that lead to the London force attractions are what attract one **nonpolar** molecule to its neighbors.

London forces increase with the size of the molecules.

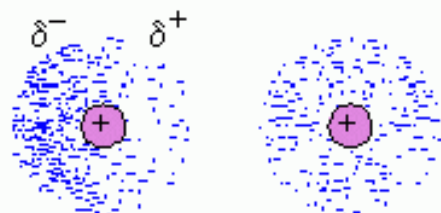


London Dispersion Forces



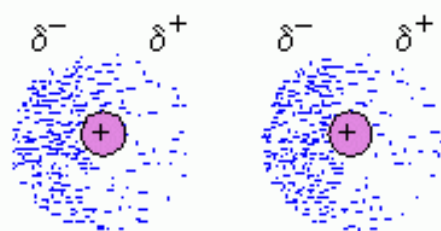
Atom A Atom B

No polarization

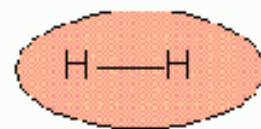


Atom A Atom B

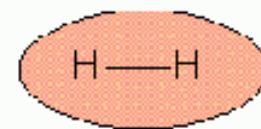
Instantaneous dipole on atom A
induces a dipole on atom B



Atom A Atom B

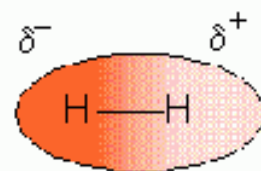


Molecule A

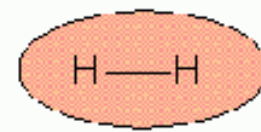


Molecule B

No polarization

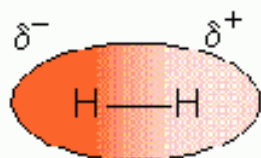


Molecule A

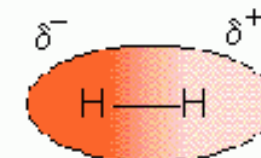


Molecule B

Instantaneous dipole on molecule A
induces a dipole on molecule B

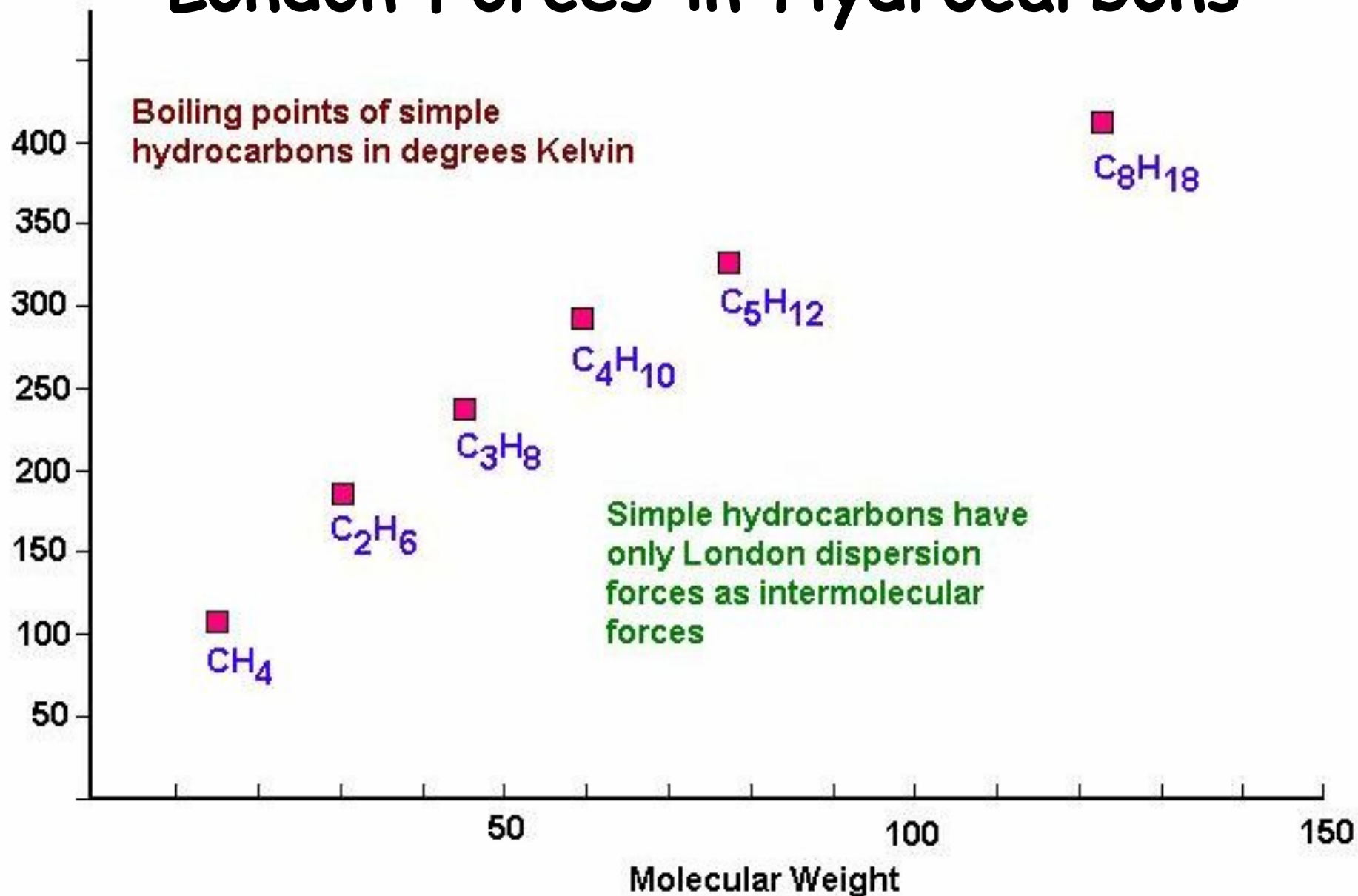


Molecule A



Molecule B

London Forces in Hydrocarbons



Summary of intermolecular forces

Hydrogen bonding	Dipole-dipole	LDF (London Dispersion Forces)
Occurs between molecules that are polar and have H-F, H-O or H-N bonds.	Occurs in polar molecules that do not have hydrogen bonding. Weaker than H-bond	Occurs in non-polar molecules. The weakest interaction.
Caused by attraction of highly electronegative and small F,O,N with hydrogen.	Caused by attraction of oppositely charged poles of molecules	Caused by attraction of atoms when their electrons are unequally distributed around the molecule for an instant of time.
Strongest	strong	Weak - gets stronger with more electrons. ex. He-weak Ar-Stronger

Relative Magnitudes of Forces

The types of bonding forces vary in their strength as measured by average bond energy.

Strongest

Covalent bonds (400 kcal/mol)

Ionic bonds

Hydrogen bonding (12-16 kcal/mol)

Dipole-dipole interactions (2-0.5 kcal/mol)

Weakest

London dispersion forces (less than 1 kcal/mol)

