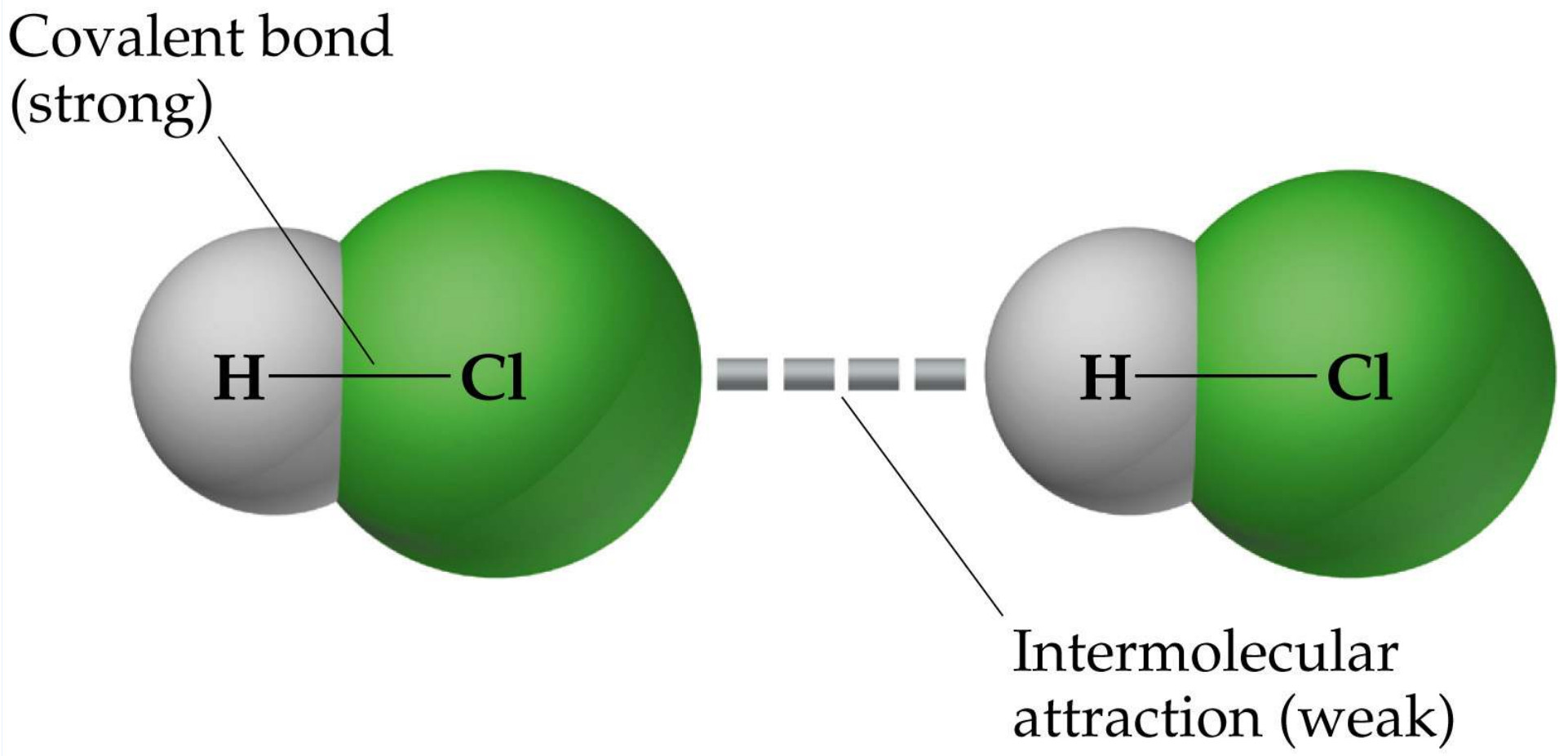
Intermolecular Forces

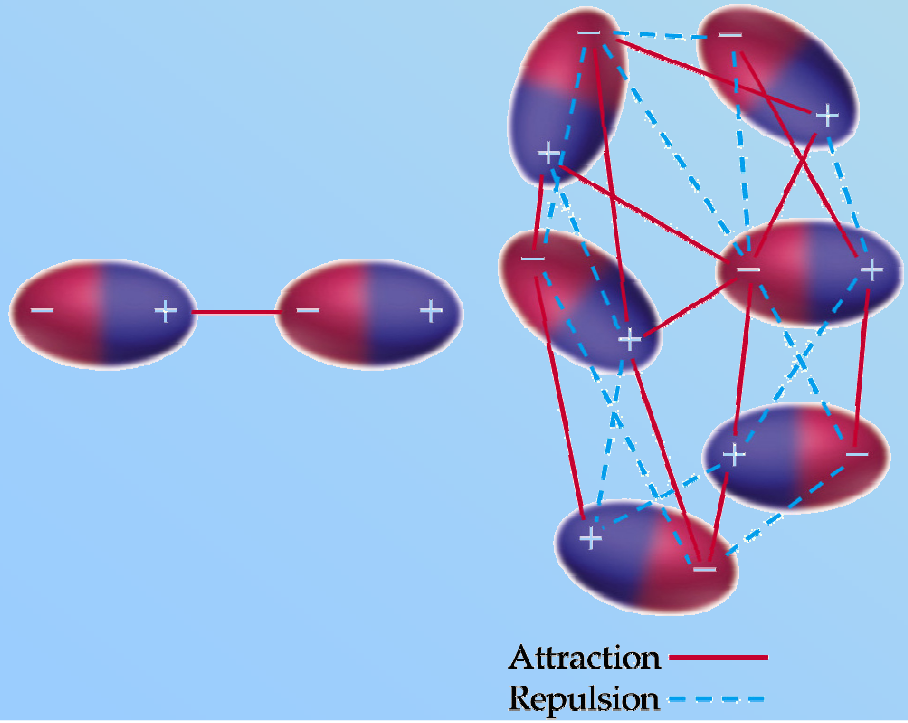
- The covalent bond holding a molecule together is an **intramolecular** force.
- The attraction between molecules is an **intermolecular** force.
- Intermolecular forces are much weaker than intramolecular forces (e.g. 16 kJ/mol vs. 431 kJ/mol for HCl).
- When a substance melts or boils the intermolecular forces are broken (not the covalent bonds).


Covalent bond
(strong)
H
Cl
H
Cl
Intermolecular
attraction (weak)

Intermolecular Forces

Dipole-dipole forces – Attraction between polar molecules (also called dipoles).

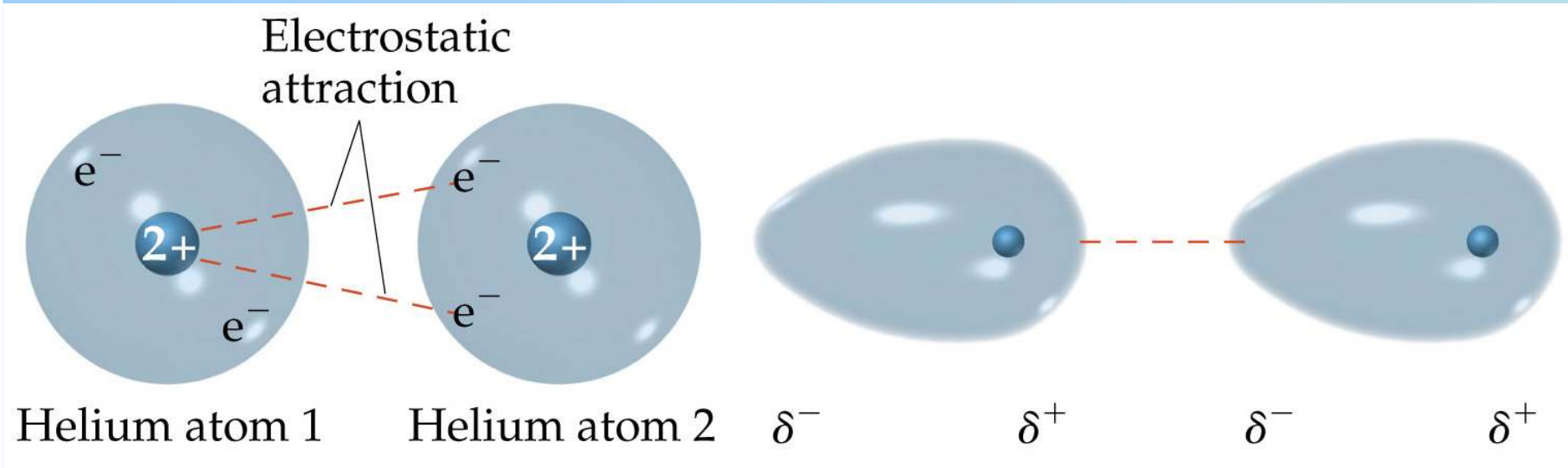
Molecules are aligned with the “partial positive” end of one molecule near the “partial negative” end of another.



London Dispersion Forces

- Weakest of all intermolecular forces.
- It is possible for two adjacent neutral molecules to affect each other.
- The nucleus of one molecule (or atom) attracts the electrons of the adjacent molecule (or atom).
- For an instant, the electron clouds become distorted.
- In that instant a dipole is formed (called an instantaneous dipole).

- One instantaneous dipole can induce another instantaneous dipole in an adjacent molecule (or atom).
- The forces between instantaneous dipoles are called **London dispersion forces**.

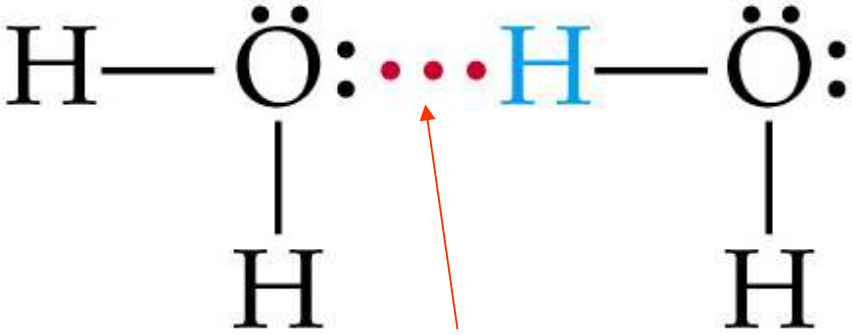


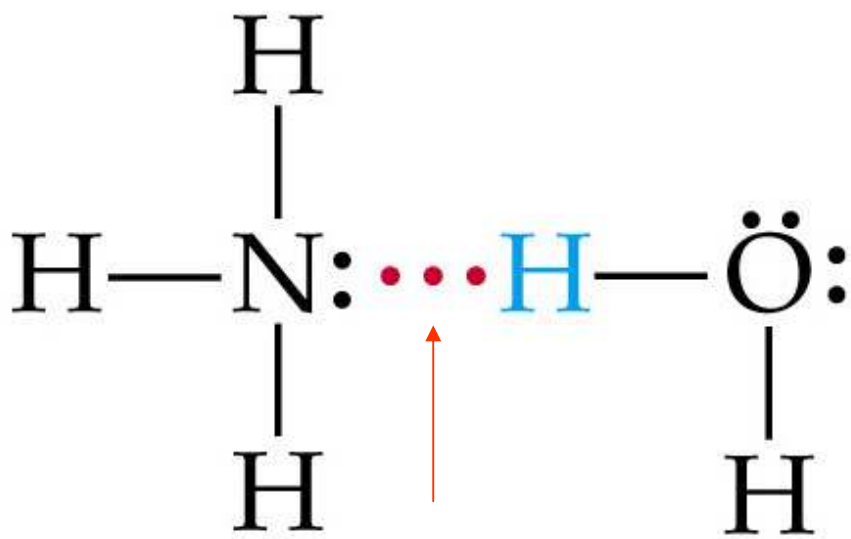
Hydrogen Bonding

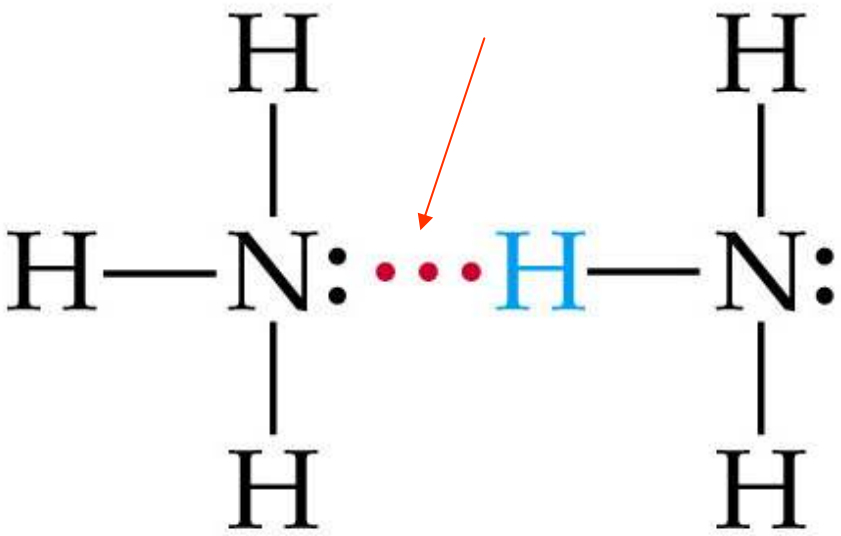
- Special case of dipole-dipole forces.
- By experiments: boiling points of compounds with H-F, H-O, and H-N bonds are abnormally high.
- Intermolecular forces are abnormally strong.

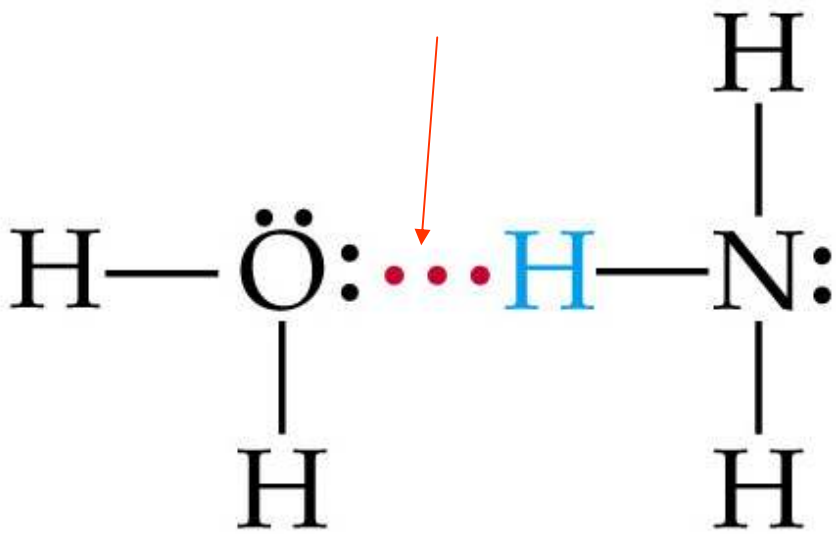
- H-bonding requires H bonded to an electronegative element (most important for compounds of F, O, and N).
  - Electrons in the H-X (X = electronegative element) lie much closer to X than H.
  - H has only one electron, so in the H-X bond, the $\delta+$ H presents an almost bare proton to the $\delta-$ X.
  - Therefore, H-bonds are strong.

Hydrogen Bonding









Summary of Intermolecular Forces

- Nonpolar – contains only London dispersion forces (LDF)
- Polar – contains LDF and dipole-dipole forces
- Polar with H bonded to N, O, or F (with unshared pair) – contains LDF, dipole-dipole forces, and hydrogen bonds.
- Larger molecule, stronger LDF (all other factors equal)