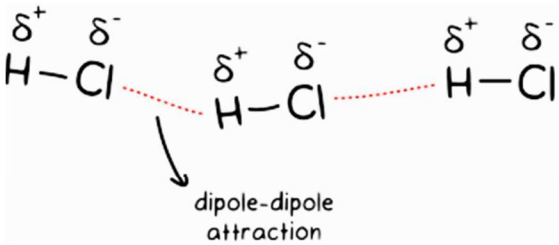
Non-covalent and Intermolecular Forces

Principle: multiple types of non-covalent forces determine the physical properties of substances such as physical state, density, and solubility in water.

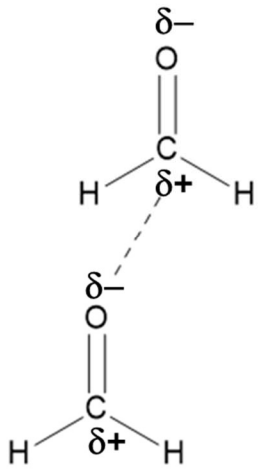
Non-covalent (NC) force: any bonding force or interaction that is not described by covalent bonds. It includes the forces **between** individual atoms, molecules and ions.

Intermolecular force (IMF): any bonding force **between** molecules (does not include ions). There are three types of IMF: dispersion forces, dipole-dipole bonds, and hydrogen bonds. Only some instructors will cover dispersion forces.

- **Dipole-dipole bonds**: these occur **between** polar molecules. In the example on the left below, a partially negatively charged Cl atom from one molecule is attracted to the partially positively charged hydrogen atom on a **different** molecule. In the example on the right, the attraction is between partially positively charged carbon in one molecule and partially negatively charged oxygen on a **different** molecule.



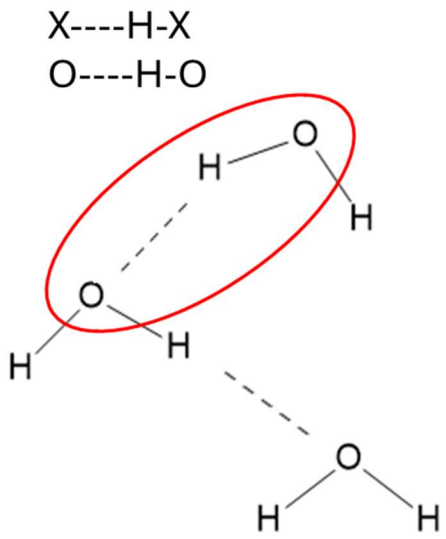
https://www.khanacademy.org/test-prep/mcat/chemical-processes/covalent-bonds/a/intramolecular-and-intermolecular-forces



- **Hydrogen bonds**: these occur between molecules that have hydrogen covalenty bonded to oxygen or nitrogen (or fluorine, which is not normally present in living organisms). Hydrogen bonding can be described by:

R-X-H ---------X-R

Where R is any collection of atoms and X is oxygen, nitrogen or fluorine. Hydrogen bonding in water fits this pattern:



1. Define each of the following:

A. Covalent bond

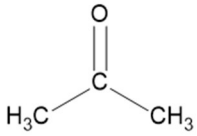
B. Polar covalent bond

C. Dipole-dipole bond

D. Hydrogen bond

2. For each of the following: a. draw the LDS of the structure showing polar covalent bonds using dipole arrows and partial charges. b. draw two additional LDS structures of the substance and then show the dipole-dipole or hydrogen bonds that exist **between** the three molecules. Lable the bonds showing the intermolecular force.

Acetone (dipole-dipole)



Methanol (hydrogen bond)

CH_3OH

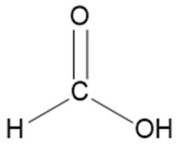
Chloromethane (dipole-dipole)

CH_3Cl

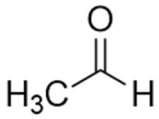
Ammonia (hydrogen bond)

NH_3

Formic acid (hydrogen bond)



3. Does the molecule shown (ethanal) posses hydrogen bonding? Why or why not? Explain in detail.



Dispersion forces (complete only if your instructor covers dispersion forces).

4. For each pair of molecules below, indicate which will have the higher boiling temperature. In each case, defend your answer by discussing the connection between magnitude of IMF in the molecules vs their relative boiling points.

A. C_2H_6, C_4H_{10}

B. Br_2, Cl_2

C. Xe, Ar