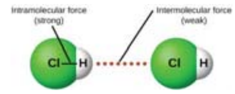
Intermolecular Forces

Additional resource visit:
http://www.youtube.com/watch?v=S8QsLUO_tgQ



Intramolecular Force vs. **Intermolecular Force**

Intramolecular Force
- within a molecule
- holds atoms together

Intermolecular Force
- between different molecules
- **dictated** by types of bonds & molecule shape

Ionic Bonds | **Covalent Bonds**

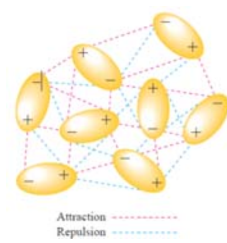
Non-polar covalent: Electrons are **equally** shared

Polar covalent: Electrons are **unequally** shared

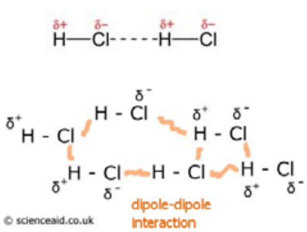
Intermolecular forces (IMF)

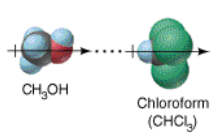
- forces of attraction between molecules
  - dictated by attraction between **positive** and **negative** ends of adjacent molecules
- degree of strength determines physical properties:
  - state of matter
  - melting/boiling point
  - hardness
  - solubility
  - viscosity
  - surface tension

1. **Dipole-Dipole Forces (DDF)**
   - relatively strong force
   - attraction between **polar** molecules
     - positive and negative dipoles of adjacent molecules line up with one another
   - spontaneous arrangement:
     - maximize number of attractive interactions; minimize number of repulsive interactions



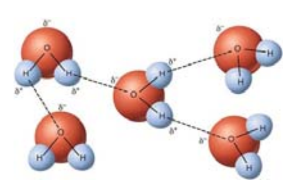
The **more polar** the molecule, the **stronger** the forces that exist between them.
- higher ΔEN





2. **Hydrogen "bonds" (H-bonds)**
   - special case of dipole-dipole force
     - **stronger** than regular dipole-dipole
   - occurs in molecules where H is bonded to **highly electronegative** atom
     - very large ΔEN → significant positive and negative dipoles
     - strengthens the effects of dipole-dipole attraction

nitrogen (N)
oxygen (O)
fluorine (F)

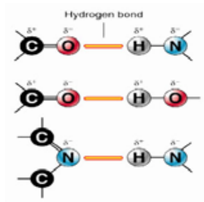


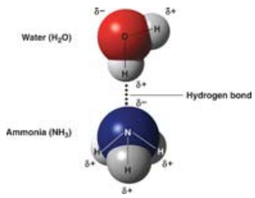
Only between molecules containing the following bonds:

- **N**-H
- **O**-H
- **F**-H

What's so special about these three atoms?

- high electronegativity → very polar bond
- small size → allows close approach





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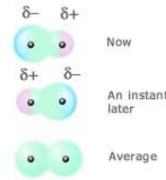
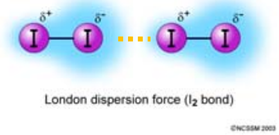
3. <u>**London Dispersion Forces (LDF)**</u>
   - weak attractive force
   - experienced by <u>all</u> molecules (polar AND **non-polar**)
   - temporary imbalance in distribution of electrons causes a transient, **fluctuating** dipole
     - temporary dipoles of adjacent molecules attract each other

blue cloud = electron density

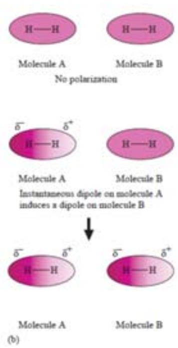
Even in a non-polar molecule, electrons can be momentarily concentrated at one end → ∂-





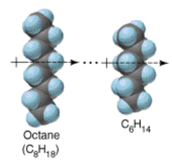
The temporary dipole on one molecule is strong enough to **induce** the opposite dipole on a neighbouring molecule.

- opposite dipoles attract



For non-polar molecules, the molecule's **size** influences the strength of LDF:

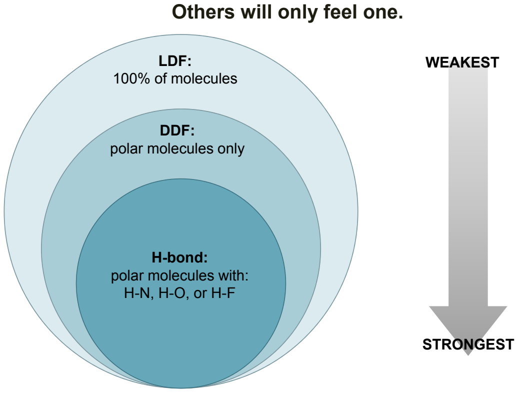
- the **larger** the molecule, the more electrons it has
  - more electrons = **larger number of LDF** → **stronger** forces
  - more electrons = larger electron cloud → **more polarizable** → **stronger** forces

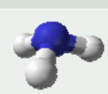
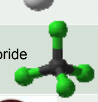
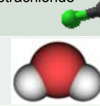


Hydrocarbons are all non-polar.

Even these molecules experience LDF.

Some molecules will feel all three forces.
Others will only feel one.



Molecule	Polar/ Non-polar?	LDF	Dipole-dipole	H-bond
hydrogen chloride, HCl 				
NH_3, ammonia 				
CCl_4, carbon tetrachloride 				
H_2O, water 				

An important feature of polarity: "Like Dissolves Like":

- polar substances only dissolve in polar solvents
- non-polar substances only dissolve in non-polar solvents

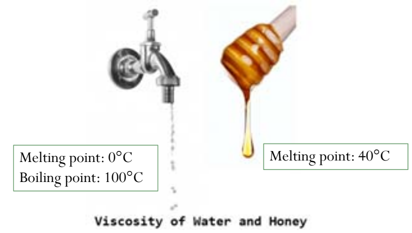
- lack of attraction between polar and non-polar molecules

e.g., - salt (NaCl) dissolves in water
- oil and water don't mix

The number of intermolecular forces between molecules dictates the physical properties of a substance.

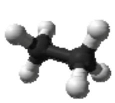
Substances with lots of strong intermolecular forces:

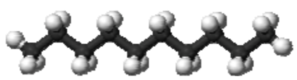
- solid at room temperature (next highest = liquid; weakest = gas)
- hard to break/crush
- high melting and boiling points
- high surface tension
- high viscosity



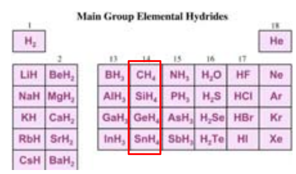
Both of these hydrocarbons are non-polar:

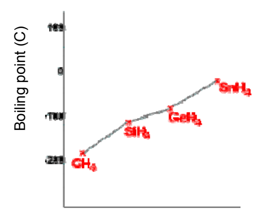
- C-H bond is non-polar
- tetrahedral arrangement of H around carbon centres

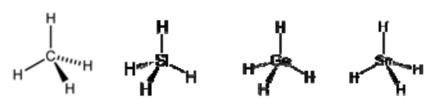

Ethane, C_2H_6


Decane, $C_{10}H_{22}$

Which is more likely to be a gas at room temperature?







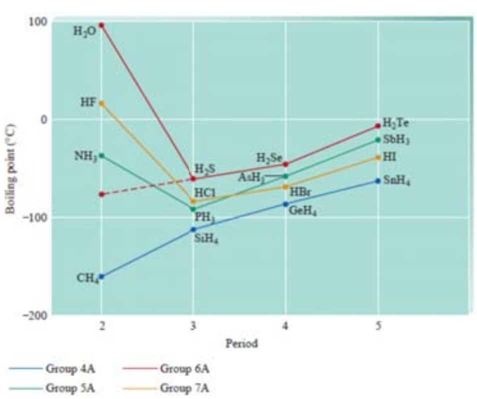
Group 14 Hydrides

- similar structures
- all non-polar

Trend in boiling point?

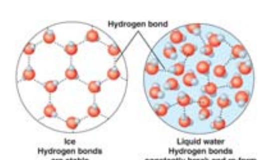
<u>Down a group:</u>
Larger molecules have higher boiling points, because of more LDF

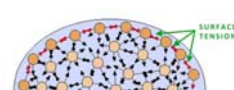
Anomaly??

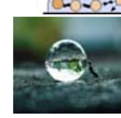


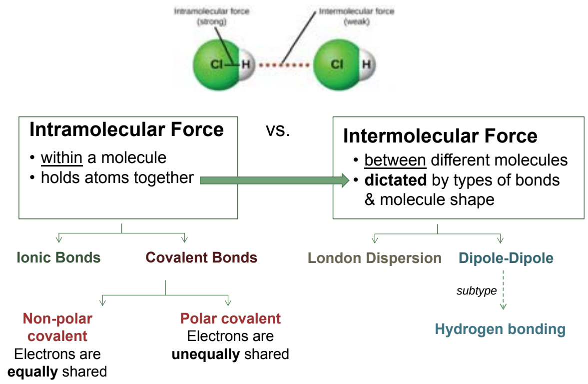
Water has many unique properties due to its ability to hydrogen bond.

- unusually high melting and boiling points
- less dense when solid (ice)
- high **surface tension** – the ability to resist an increase in its surface area
- high **specific heat capacity** – the energy required to raise its temperature by 1°C









Summary

- There are three main types of intermolecular forces that hold different molecules to each other.
  - All are fundamentally based on the attraction between oppositely-charged ends of molecules.
- The relative number/strength of IMF that molecules experience in each others' presence will dictate observable physical properties.
  - Differs for each molecule → Different compounds have different properties.
- Water's important unique physical properties come from its ability to form hydrogen bonds.

Homework

- Pg. 115 #1, 3-7
- Pg. 118 #2-4, 6