



Or...

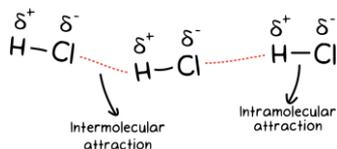
- Why do some solids dissolve in water but others do not?
- Why are some substances gases at room temperature, but others are liquid or solid?
- What gives metals the ability to conduct electricity, what makes non-metals brittle?
- The answers have to do with ...

Intermolecular forces

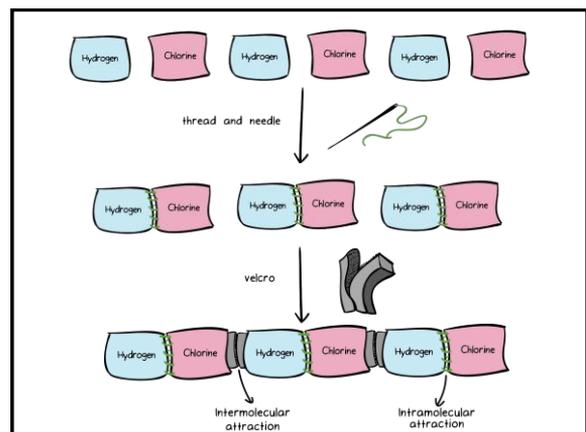
Intra Vs Intermolecular Forces

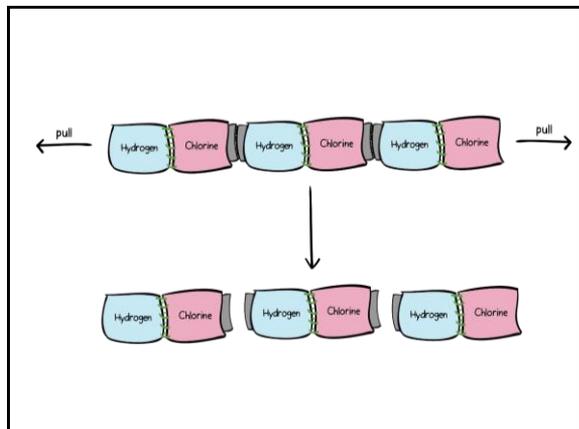
- We've just looked at intramolecular forces, ones that act *within* molecules to hold them together.
- Intermolecular forces are forces of attraction *between*, rather than within, molecules.

Intra Vs Intermolecular Forces



- In general, intermolecular forces are considerably weaker than intramolecular.





Intermolecular Forces (IMF)

- Changes in state are due to changes in intermolecular forces.
- The forces within the atoms don't change, but the ones between the molecules do.

1. London Dispersion Forces

- Weakest attractive force
- Caused by instantaneous dipoles that form when electrons happen to be on the same side of a molecule

It is not a permanent partial charge

Electrostatic attraction

Helium atom 1 Helium atom 2

Even Distribution of electrons

Temporary Uneven distribution of electrons which causes a temporary attraction

1. London Dispersion Forces

- All molecules experience London Dispersion Forces, but they have the greatest impact in non polar molecules.
- Strength increases as mass increases due to more electrons. E.g. boiling points:

H ₂	-253°C
O ₂	-183°C
Cl ₂	-34°C
Br ₂	+59°C

2. Dipole-Dipole Forces

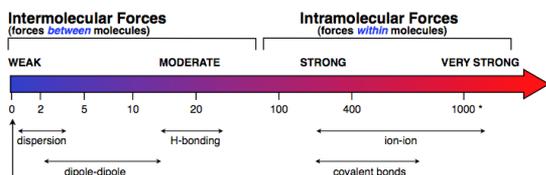
- The electrostatic attraction caused when dipoles of polar molecules position their positive and negative ends near each other.

2. Dipole-Dipole Forces

- Only polar molecules experience Dipole-Dipole forces
- Stronger than London Dispersion forces (but are still only 1% as strong as covalent or ionic bonds)
- Strength increases with increasing polarity and decreasing distance between molecules

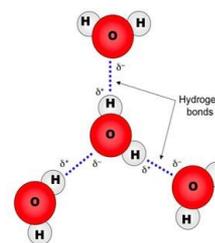
3. Hydrogen Bond

- Special type of dipole-dipole identified for its strength (but still 10-20 times weaker than covalent bonds)

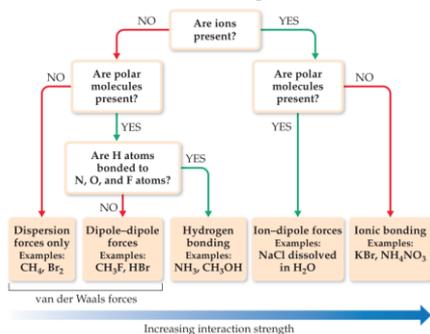


3. Hydrogen Bond

- Occurs when a hydrogen atom bonded to a small highly electronegative atom (oxygen, nitrogen, or fluorine) is attracted to a partially negative atom on a nearby molecule



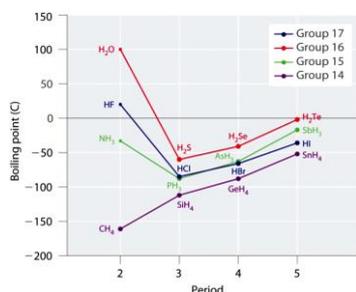
Summarizing IMFs



Why are IMFs important?

- The stronger the IMFs are, the more attraction between molecules and the more energy it will require to pull the molecules apart.
- As such, many physical properties (such as boiling point, freezing point, surface tension) are dependent on the nature of the IMFs.

Boiling Points



Why does BP↑ as period ↑?
Why are some BP high at period 2?

Boiling Points

- Group 14 (non-polar molecules) show us that BPs increase down a group as molar mass increases
 - larger size means greater London forces
- Groups 15, 16 and 17 are polar resulting in higher BP than their non-polar counterparts
- Unexpectedly high BPs occur in Period 2 (H_2O , HF, and NH_3) because of hydrogen bonding.

Freezing Points

- The stronger the IMF, the higher the freezing point.

Freezing Points

Element	Freezing point (°C)
helium	-269.7
neon	-248.6
argon	-189.4
krypton	-157.3
xenon	-111.9

Why does FP decrease as period ↑?

Freezing Points

- Even in non-polar molecules, London dispersion forces can be strong enough to form a solid in cold temperatures.
- FP generally decrease down a group as electrons become further from the nucleus and are more susceptible to deformation.

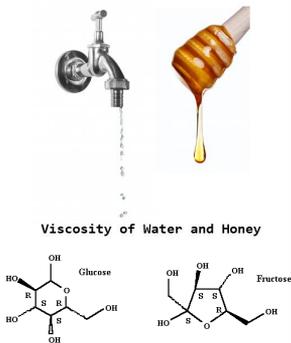
Surface Tension

- The stronger the IMFs, the greater the surface tension (adhesion of molecules).
- Hydrogen bonds make water have higher surface tension than most liquids.



Viscosity

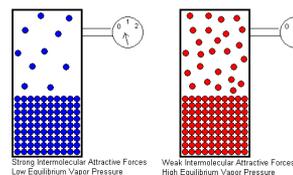
- The stronger the IMFs, the more viscous the liquid (meaning it flows more easily).



- Eg: Honey is more viscous than water

Vapour Pressure

- The pressure of gas above a liquid sample in a closed container will decrease with stronger IMFs.



In Summary

Molecules that have stronger IMFs will have:

- higher freezing points, boiling points, surface tension and viscosity
- and lower vapour pressures

than molecules with weaker IMFs.

Example 1:

- Give an explanation in terms of IMF for the difference in boiling point between HF (20°C) and HCl (-85°C).

Example 2:

- Give an explanation in terms of IMF for the difference in viscosity between H₂O and glycerol (C₃H₈O₃).