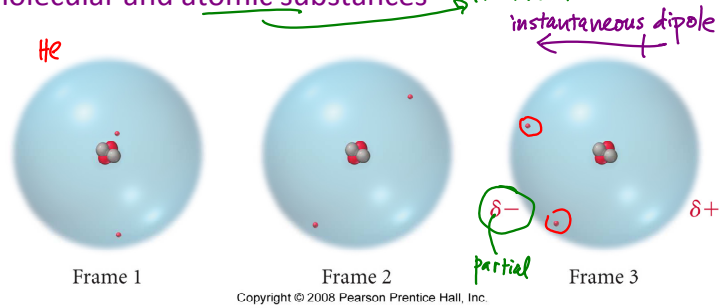
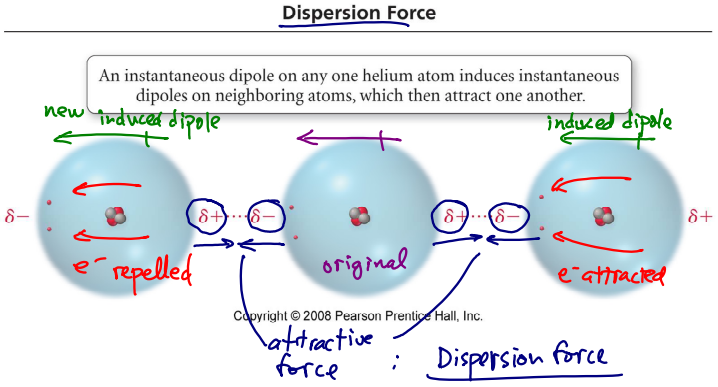
Dispersion force

There are several types of intermolecular forces: between molecules

- **Dispersion forces**: all substances
- **Dipole-dipole forces**: polar substances
- **Hydrogen bonding**: substances with electropositive H
- **Ion-dipole forces**: dissolved ionic compounds

Dispersion forces (aka London forces): present in all molecular and atomic substances He, Ne, etc.





Trends in dispersion forces

The strength of dispersion forces comes from the ability of the electron cloud to move and polarize.

- Large molecules have stronger dispersion forces than smaller molecules most influence (MM)
  - Straight-chain substances have more surface area and stronger dispersion forces than branched substances of similar molar mass vs stronger disp

Which will have a higher boiling point, a substance with **strong** IMFs, or a substance with **weak** IMFs?

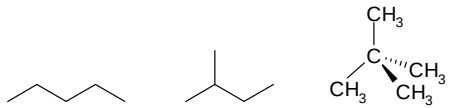
→ requires more energy to overcome IMFs.

Rank the following substances in order of increasing boiling points, from lowest to highest:

Ar, Kr, Ne, Xe → largest, strongest disp. forces = highest bp
→ weakest IMFs = lowest bp

Ne < Ar < Kr < Xe

$CH_3CH_2CH_3$, CH_4, CH_3CH_3 (CH_4 lowest, CH_3CH_3 < propane < $CH_3CH_2CH_3$ highest)

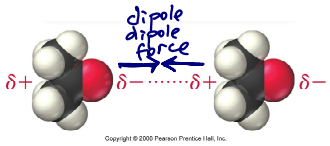


n-pentane (highest bp) isopentane neopentane (lowest bp) all isomers of C_5H_{12}

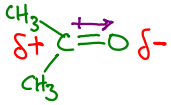
Dipole-dipole force

<u>Dipole-dipole forces</u> exist between all **polar molecules.**

Polar molecules have __permanent__ dipoles in addition to the __instantaneous__ dipoles that cause dispersion forces.

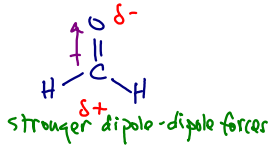


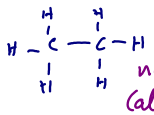
The positive end of a polar molecule is attracted to the negative end of its neighbor.



CH_2O vs CH_3CH_3

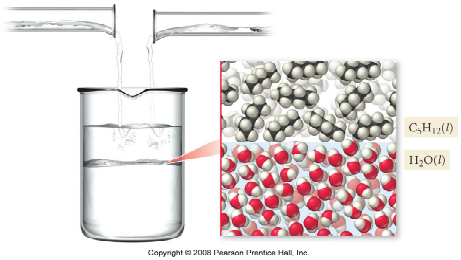
molar mass: ~30 dispersion forces have similar strength ~30

polarity:  stronger dipole-dipole forces

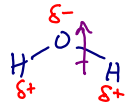
 nonpolar (all hydrocarbon)

bp rank: higher bp lower bp

Polarity determines **<u>miscibility</u>** of liquids - the ability of two substances to completely mix without separating.

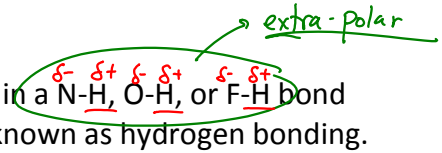


hydrocarbon = nonpolar

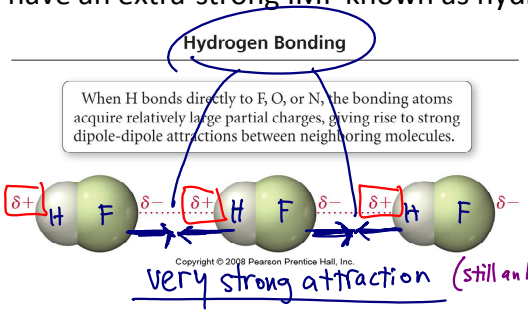
 polar

Hydrogen bonding

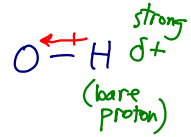
extra-polar

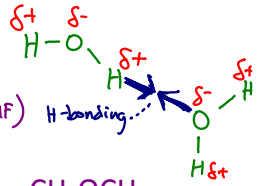


Polar molecules that contain a N-H, O-H, or F-H bond have an extra-strong IMF known as hydrogen bonding.



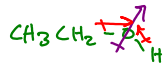
very strong attraction (still an IMF)

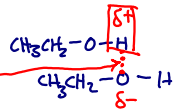




CH_3CH_2OH ethanol vs CH_3OCH_3 dimethyl ether

molar mass: 46 similar 46

polarity:  similar 

H-bonding? yes  no all H attached to C

bp rank: higher (~80°C) lower (~10°C)

Rank the following in order of increasing bp:

HBr, HCl, HF, HI

HF: H-bonding, highest bp

HCl < HBr < HI < HF

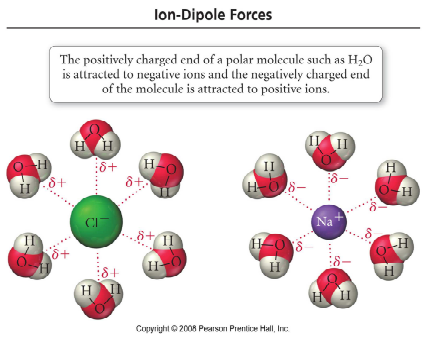
disp forces (no H-bonding) < H-bonding

F
Cl
Br
I

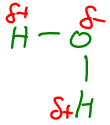
Ion-dipole force

Ion-dipole force is the attractive force between a dissolved ion and the opposite dipole of the polar solvent molecules surrounding it.

how soluble ionic compounds dissolve

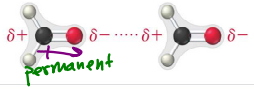
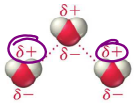
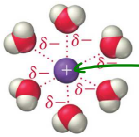


polar solvent



Intermolecular forces summary:

TABLE 11.4 Types of Intermolecular Forces

Type	Present in	Molecular perspective	Strength
Dispersion	All molecules and atoms		
Dipole-dipole	Polar molecules		
Hydrogen bonding	Molecules containing H bonded to F, O, or N		
Ion-dipole	Mixtures of ionic compounds and polar compounds		

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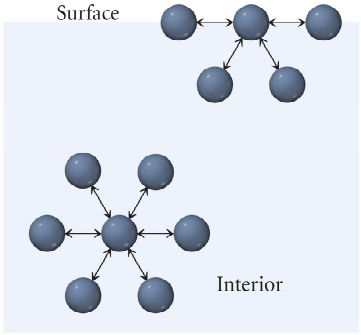
bonding forces are even stronger

Surface tension and viscosity

Surface tension: energy required to increase surface area by a unit amount

The surface of a liquid tends to minimize itself:



Fewer attractive forces on surface molecules give them higher potential energy than interior molecules.

strong IMFs = more resistance to surface changes

Viscosity also depends on intermolecular forces - strong IMFs cause liquid molecules to be less free to move and the substance has a higher viscosity

Capillary action occurs when a substance has a stronger attraction to the surface of a tube than to itself.