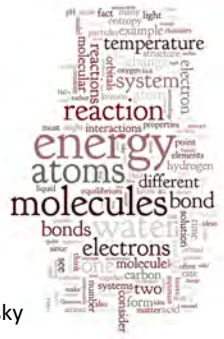
Molecular Shape, Polarity, and Properties



Chemistry, Life, the Universe & Everything – Cooper & Klymkowsky

Do molecules interact?

A. Yes
B. No
C. DK

How do molecules interact?

Types of intermolecular forces

- London dispersion forces
  - Temporary fluctuating dipoles
  - Depends on size, surface area, and shape of the molecule
  - For non-polar molecules this is the only force present
  - Present in ALL substances
  - Examples?
  - CH_4, CO_2, Hydrocarbons (only CH), Br_2

What do you think the BP trend would be for?

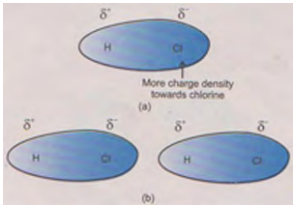
CH_4, NH_3, H_2O, HF, Ne

Compound	Molar mass g/mole
CH_4	16
NH_3	17
H_2O	18
HF	20
Ne	20

Bond type	bond length (pm)	atomic radius (pm)
C–H (in CH_4)	109	C - 70
N–H in (NH_3)	101	N - 65
O–H (in H_2O)	96	O - 60
F–H in (HF)	92	F - 50
not applicable	not applicable	Ne - 38

Types of intermolecular forces

- Dipole-dipole
  - Present in polar substances (along with LDF)
  - Typically stronger than LDF
  - Examples?
  - HCl, CH_3F, CH_2O, CH_3OCH_3



What effect would polarity have on:

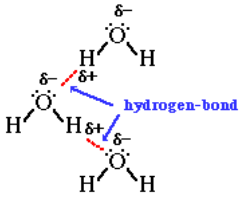
- The strength of the intermolecular force?
    A. Increase
    B. Decrease
    C. Same
    D. DK
- The mp and bp of the substances?

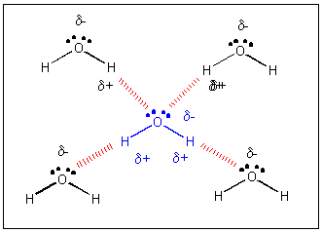
Effect of polarity of molecule

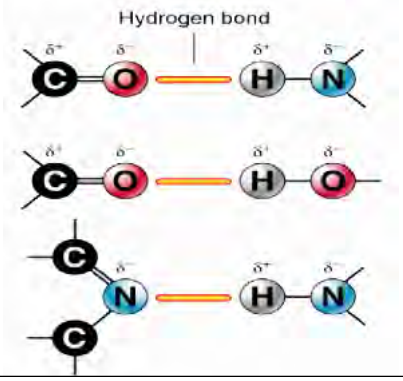
- Polar molecules have stronger intermolecular interactions (than similar non-polar molecules)
- Therefore they stick together more strongly and have higher mp and bp (and other properties)

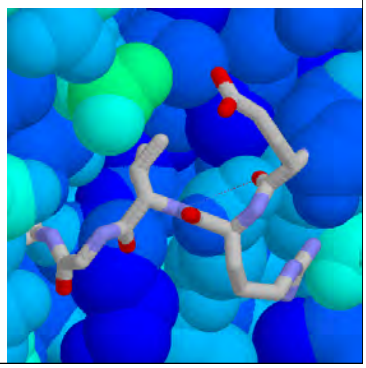
Types of intermolecular forces

- Hydrogen Bonding
  - Present in compounds with H covalently bonded to O, N or F
  - The bond is highly polarized (charge separated)
  - The interactions **with other molecules** are stronger
  - Compounds with H-bonding also have dipole-dipole and LDF
  - Examples?
  - H_2O, CH_3OH, CH_3CH_2OH









What type of IMF present in?

- He
- H_2
- CH_4
- NH_3
- H_2O
- CO_2

- 4K
- 20K
- 112K
- 240K
- 373K
- 217K

Class Activity

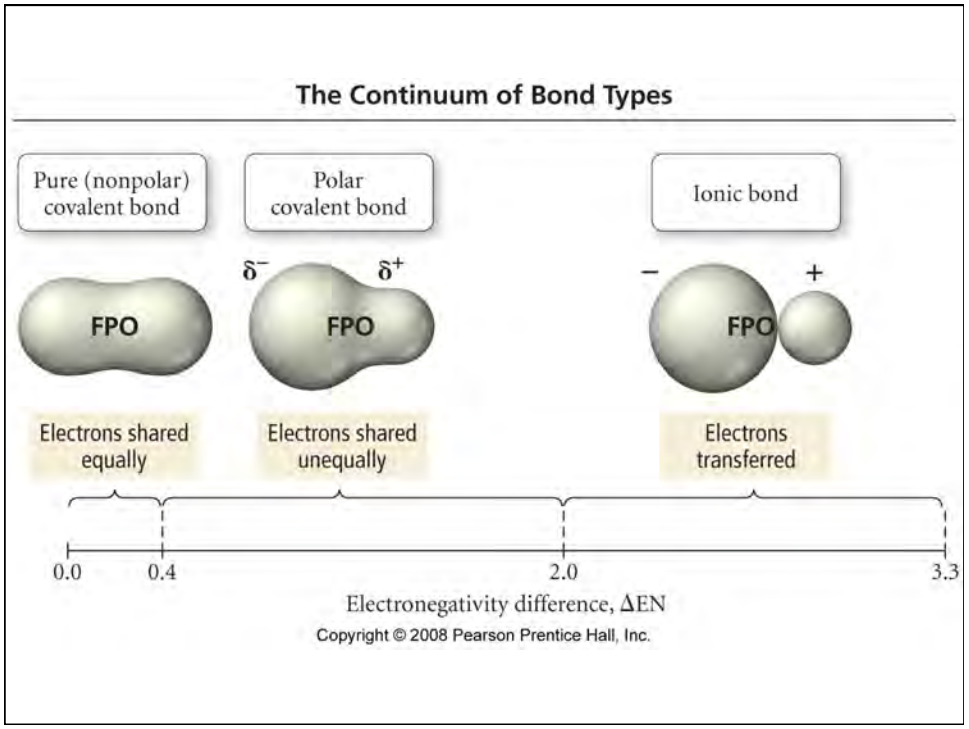
1. Draw out 4 molecules of HF showing how they interact with each other
2. Draw out 4 molecules of H_2O showing how they interact with each other
3. Draw out 4 molecules of CH_3CH_2OH showing how they interact with each other
4. Draw out 4 molecules of CH_3OCH_3 showing how they interact with each other

Water

- Properties of water are anomalous (compared to other similar materials)
- High mp, bp, specific heat,
- Low vapor pressure
- Density of ice < liquid water
- Huge consequences for life!

Questions

- Why are the interactions between H_2O molecules stronger than those between HF molecules, even though the polarity of the HF bond is larger than the polarity of the OH bond.
- Why don't more than four water molecules interact with a central water molecule?
- What would you predict would be the relative boiling points of methanol (CH_3OH) and ethane (CH_3CH_3) - which have similar molecular weights? Explain your answer
- What would you predict would be the relative boiling points of methanol (CH_3OH) and ethanol (CH_3CH_2OH)? Explain your answer
- What kind of compound (or what structural feature) would you expect might be attracted to the $\delta+$ located on the carbon of methanol?


The Continuum of Bond Types
Pure (nonpolar) covalent bond
Polar covalent bond
Ionic bond
δ−
δ+
−
+
FPO
FPO
FPO
Electrons shared equally
Electrons shared unequally
Electrons transferred
0.0
0.4
2.0
3.3
Electronegativity difference, ΔEN
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