Lecture 20: Intermolecular forces 2

**Read:** BLB 11.1–2; 11.6  
**HW:** BLB 11.9,15,21,23,25,27  
Sup 11:1–4

**Know:**  
- intermolecular forces  
  - ion-dipole  
  - dipole-dipole  
  - London dispersion forces  
  - hydrogen bonds  
- phase diagrams

**Exam #2:** Monday, March 2 @ 6:30; review previous material, so you **UNDERSTAND** what we’ve done and what we are doing now, and start preparing now!

**Final Exam:** Monday, May 4 @ 12:20; MUST register on elion for a final exam conflict or overload by March 8. See
http://www.registrar.psu.edu/exams/exam_overload.cfm  
http://www.psu.edu/dus/handbook/exam.html#conflict

**Need help?? Get help!!** TAs in CRC (211 Whitmore) and Supplemental Instruction (SI)—hours on Chem 110 website; Sheets office hours: Mon 12:30–2; Tue 10:30–12 in 324 (or 326 Chem Bldg)
Hydrogen bonding

- **hydrogen bonding** (**H bonding**): H covalently bonded to a very **electronegative** atom (**N**, **O**, **F**) interacts with lone pairs of **e\(^-\)** on **N**, **O**, **F** of another molecule; **dipole-dipole IMF**; “directional” similar to covalent bonds

- **H bond energies**: ~ 4–25 kJ/mole, which is strong as intermolecular forces go but much weaker as compared to covalent bonds
Hydrogen bonding (cont.)

H bonding:
why ice floats on water
double helix in DNA
α-helix in proteins
Water, water everywhere…

• **H-bonding**: IM force **BUT** “directional” ala a covalent bond; it’s a **directional dipole-dipole IMF**

• **manifestations of strong IM forces in water**
  - high surface tension
  - capillary action in plants
  - high specific heat
  - moderate temperatures near oceans/lakes
  - high heat of vaporization
  - regulation of body temperature (sweat)
  - condensation in clouds fuels thunder storms

• because H-bonding occurs…
  - ice floating on water: ice has lower density than liquid water (note *backward slope* on phase diagram); ice on surface of lakes (oceans) insulates rest of water; keeps entire lake & oceans from freezing

  ice melts as pressure increases (ice skating)
H-bonding in your body

• H-bonding allows you (and every other lifeform) to exist—really!!

• DNA, RNA, proteins are biological polymers

• **polymers** are high molecular weight materials formed from many small molecules, which are called **monomers** (repeating unit)

  \[
  \text{monomers} \rightarrow \text{polymers} \\
  \text{nucleotides} \rightarrow \text{RNA, DNA} \\
  \text{amino acids} \rightarrow \text{proteins}
  \]
H-bonding in DNA

• nucleotides: 4 bases; H-bond in specific pairs
  adenine—thymine
  guanine—cytosine

[BLB Figs. 25.40, 25.41, & 25.42]

• H bonds stabilize double helix structure & play critical role in replication

H-bonding in proteins

• protein folding—e.g., $\alpha$-helix [BLB Fig. 25.26]

• protein-protein interactions/recognition (e.g., signaling)
What intermolecular forces are present??

interacting molecules or ions

ions involved?

no

polar molecules involved?

no

LDF only

dipole–dipole (& LDF)

no

any H bonded to N, O, or F?

yes

H-bond (& LDF & dipole–dipole)

yes

are ions & polar molecules present?

no

ionic bonding

yes

ion-dipole (& LDF & dipole–dipole)
How do you know which molecule has the strongest IM forces?

• compare boiling points & melting points

• **BP** (MP) means **stronger** IM forces

• if substances are similar, follow trends

*example:* inert gases have similar shapes
IM forces $\uparrow$ as MW $\uparrow$ ($\alpha \uparrow$) (Lecture 19, p 14)

• **competing trends??** need BP or MP

<table>
<thead>
<tr>
<th></th>
<th>$\mu$</th>
<th>size ($\alpha$)</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH$_3$Cl</td>
<td>1.87 D</td>
<td></td>
<td>–24.2°C</td>
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<tr>
<td>CH$_3$Br</td>
<td>1.81 D</td>
<td></td>
<td>3.6°C</td>
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<tr>
<td>CH$_3$I</td>
<td>1.62 D</td>
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<td>42.4°C</td>
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LDF dominate in this *particular* example
Let’s compare strength of IM forces for different functional groups

<table>
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<tr>
<th>functional group</th>
<th>BP</th>
<th>structure</th>
<th>MW (g/mol)</th>
<th>IM forces at work</th>
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<tbody>
<tr>
<td>hydrocarbon</td>
<td>36°C</td>
<td>CH₃CH₂CH₂CH₂CH₂—CH₃</td>
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<tr>
<td>aldehyde</td>
<td>75°C</td>
<td>CH₃CH₂CH₂—C,H</td>
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<tr>
<td>ketone</td>
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<td>CH₃CH₂—C—CH₃</td>
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<tr>
<td>ether</td>
<td>34°C</td>
<td>CH₃CH₂—O—CH₂CH₃</td>
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<tr>
<td>ester</td>
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<td>CH₃—C—OCH₃</td>
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<td>carboxylic acid</td>
<td>141°C</td>
<td>CH₃CH₂—C—OH</td>
<td>74</td>
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</table>
Before next class:

**Review:** Lectures 13–20: Chap 3, 9 & organic chem.

Please bring any *last minute* questions you may have. This is for touch-up or clarification questions, NOT a lecture repeat! Bring printouts!!!