Announcements & Agenda (02/07/07)

- Exam @ 11 am this Friday (Start = 10:45 am)
  - Review Wed @ 3 pm, Here (SC 1019)
  - Covers Ch 1-5 + Intermolecular Forces (Notes) + Lab
  - WILL NOT include Ch 7 except the notes from today

Today
- Intermolecular Forces (Notes: Will be on Exam)
- Exam Procedures
- Exam Topics

Last Time: Energy of Chemical Rxns

- The activation energy is the minimum energy needed for a reaction to take place.
- When a collision provides energy equal to or greater than the activation energy, product can form.

Summary of Endo- & Exothermic Rxns

<table>
<thead>
<tr>
<th>Reaction Type</th>
<th>Energy Change in Reaction</th>
<th>Heat in Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endothermic</td>
<td>Heat absorbed</td>
<td>Reactant</td>
</tr>
<tr>
<td>Exothermic</td>
<td>Heat released</td>
<td>Product</td>
</tr>
</tbody>
</table>

Summary of Reaction Rates

State the effect of each on the rate of reaction as:

1) increases  2) decreases  3) no change

A. increasing the temperature. 1
B. removing some of the reactants. 2
C. adding a catalyst. 1
D. placing the reaction flask in ice. 2
E. increasing the concentration of one of the reactants. 1
Intermolecular Forces (Notes Only)

Inter- vs. Intra-

Latin: Between Among molecules molecules

3 types:
- Dispersion Forces
- Dipolar Forces
- Hydrogen Bonding

Melting & Boiling Points

Both are indicators of the strengths of intermolecular forces:
- Freezing point (fp): the temperature at which a solid & liquid coexist at equilibrium under ‘normal’ pressures
- Boiling point (bp): the temperature at which a liquid & vapor coexist at equilibrium under ‘normal’ pressures

Exam Questions:
(a) Rank Compounds by BPs OR
(b) Explain why one compound has a higher bp/mp than another based on IM forces OR
(c) Be able to make a sketch showing interactions between two molecules

Intermolecular forces: Actually all the same force!
- Electrostatic
  - Dispersion Forces: From polarizability of atoms
  - Dipolar Forces: From permanent dipole moments
- Hydrogen-bonding: Special case of dipolar forces

... but remember that intermolecular forces are weaker than covalent or ionic bonds!!!
1. Dispersion Forces

- Found in all molecular substances
- Arise from attractions involving induced dipoles.

Magnitude depends on how easy it is to polarize the electron cloud of a molecule.
- larger molecules have larger polarizability.

Intermolecular Forces

- Larger shapes are more polarizable
- Higher boiling point

Comparison of the dispersion forces in I₂ and F₂

Polarizability increases with increasing MM

Intermolecular forces not only hold small molecules in liquids and solids together, but also drive very large molecules to bind to each other - this is necessary for cell functions.
1. More on London Dispersion Forces
Individually, dispersion (van der Waal’s) forces are thought of as very weak. However, these forces between large molecules can be very strong - e.g. motor oil, vaseline are entirely non-polar molecules.
In water “hydrophobic bonding” drives large non-polar molecules or parts of molecules together.

Sodium dodecyl sulfate (= sodium lauryl sulfate)

\[
\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-SO}_3
\]

Nonpolar: Hydrophobic = “water-hating”
Ionic: Hydrophilic = “water loving”

2. Dipolar Forces
- Occur when one polar molecule encounters another polar molecule.
- The positive ends will be attracted to the negative ends.
- Dipolar forces are typically stronger than dispersion forces.
- Dipolar forces increase with an increase in the polarity of the molecule.
- NOTE: Ion-dipole forces stronger than dipolar forces.

Example
Explain the trend in bp’s: butane (0°C), methyl ethyl ether (8°C) and acetone (56°C).

Higher boiling point ⇒
3. Hydrogen Bonding

- Special case of dipole-dipole forces.
- By experiments: boiling points of compounds with H-F, H-O, and H-N bonds are abnormally high.
- Intermolecular forces are abnormally strong.

Hydrogen Bonding

\[
\begin{align*}
H & \cdots O & H & \cdots O \\
\vdots & & \vdots & \\
H & & H & N \cdots H & \cdots O \\
\vdots & & \vdots & & \vdots \\
H & & H & & H \\
\end{align*}
\]

Examples of hydrogen bonding among some small molecules

- Hydrogen fluoride
- Ammonia-water
- Water-ethanol

Electronegative atom with lone pair

- Formic acid
- Salicylic acid
- Glycine (an amino acid)
Exam Procedure (GOOD LUCK!!!)

- When you arrive, leave ALL belongings to the side of the room except pencils and a calculator
- Sit ONLY where an exam has been placed
- Academic integrity is expected
- Some things you CANNOT do:
  - You CANNOT use the programming functions on calculators
  - You CANNOT temporarily loan your calculator to a neighbor
  - You CANNOT use a cell phone or any other interactive device
- Do not begin the exam until instructed to do so (10:45)
- To be fair to everyone, you must turn in your exam when instructed (11:50)
- I will provide a Periodic Table

Big-Picture Exam Topics

- Ch 1 & 2 (~20-30 %)
  - Units, Sig. Figs., Prefixes, Problem Solving
  - Type of Energy, Energy in Nutrition, Specific Heat, Heating/Cooling Curves (States of Matter)
- Ch 3 (~20-30 %)
  - Atomic Structure, Elemental Identity, Isotopes, Radioactivity, Periodic Table & Trends, Electron Energy Levels
- Ch 4 (~20-30 %)
  - Octet Rule, Ionic & Covalent Compounds and Naming, Lewis Dots, Bond Polarity (EN), Molecular Shapes & Polarity
- Ch 5 & IM Forces (~20-30 %)
  - Balancing, Mass Conservation, Redox Reactions, Using the Mole, Energy in Chemical Reactions
  - Dispersion, Dipolar, and Hydrogen-bonding IM forces, Ranking based on BP, Sketching Interactions, Compatibility of IM forces

MC (10-15%), Short Ans. (~70%), Problem Solving (15-20%)