**Intermolecular forces**: the forces of attraction between molecules

- Boiling point is a good measure of the force of attraction between particles of a liquid
  - The higher the boiling point, the stronger the forces between particles
Molecular Polarity and Dipole-Dipole Forces

- The strongest intermolecular forces exist between polar molecules
- **Dipole**: created by equal but opposite charges that are separated by a short distance
- Caused by an unequal sharing of electrons
- Arrow points toward the more electronegative atom
- **Dipole-dipole forces**: the forces of attraction between polar molecules
  - Short-range forces acting only between nearby molecules

- A polar molecule can *induce* a dipole in a nonpolar molecule by temporarily attracting its electrons
Hydrogen Bonding:

- **Hydrogen bonding**: the intermolecular forces in which a hydrogen atom that is bonded to a highly electronegative atom is attracted to an unshared pair of electrons of an electronegative atom in a nearby molecule.
- Special type of dipole-dipole force (very polar & very strong).
- Hydrogen must be bonded to either a fluorine, oxygen, or nitrogen atom.
London Dispersion Forces

- In *any* atom or molecule, the electrons are in continuous motions
- **London dispersion forces**: the intermolecular attractions resulting from the constant motion of electrons and the creation of instantaneous dipoles
- *Not* a permanent partial charge
- London forces act between *all* atoms and molecules
- They are *only* intermolecular forces acting among noble-gas atoms and nonpolar molecules
<table>
<thead>
<tr>
<th></th>
<th><strong>LONDON DISPERSION FORCES</strong></th>
<th><strong>DIPOLE-DIPOLE FORCES</strong></th>
<th><strong>HYDROGEN BONDING</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>• Attraction between 2 instantaneous dipoles.</td>
<td>• Attraction between 2 permanent dipoles.</td>
<td>• Attraction between molecules with N-H, O-H, &amp; F-H bonds.</td>
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<tr>
<td></td>
<td>• Asymmetrical electron distribution.</td>
<td>• Polar molecules.</td>
<td>• Extremely polar bonds (\Rightarrow) very strong dipole-dipole force.</td>
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<tr>
<td></td>
<td>• All atoms &amp; molecules.</td>
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<tr>
<td><strong>Diagram</strong></td>
<td><img src="image1.png" alt="Diagram of London Dispersion Forces" /></td>
<td><img src="image2.png" alt="Diagram of Dipole-Dipole Forces" /></td>
<td><img src="image3.png" alt="Diagram of Hydrogen Bonding" /></td>
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<tr>
<td><strong>Relative Strength</strong></td>
<td>• weakest</td>
<td>• medium strength</td>
<td>• strongest</td>
</tr>
<tr>
<td><strong>Other Information</strong></td>
<td>• Increase in strength as molar mass increases (more electrons).</td>
<td>• Stronger when molecules are closer together</td>
<td>• <em>Not</em> chemical bonding</td>
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</tbody>
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