The Hydrogen Bond

**Covalent bond**: a chemical bond characterized by the ____________

example:

**Hydrogen bond**: a non-covalent interaction characterized by electrostatic attraction between an ____________

**H-bond donor**: the H covalently ________________

**H-bond acceptor**: the ________________that contributes the ________________
The Hydrogen Bond

- When H is covalently bound to ____________________________ it gives the H a partial ________________, such with in H₂O.

This partial “+” of H can then ________________ ____________________________ of electronegative atoms

Consider HF, H₂O and NH₃

- HF: H, ________________
  F, ________________

- H₂O: H, ________________
  O, ________________

- NH₃: H, ________________
  N, ________________
# The Hydrogen Bond

## Strength of H-bond

<table>
<thead>
<tr>
<th>Table 2.3</th>
<th>Some Bond Energies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Bond</strong></td>
<td><em><em>Energy</em> (kJ mol$^{-1}$)</em>*</td>
</tr>
<tr>
<td>Covalent Bonds (Strong)</td>
<td></td>
</tr>
<tr>
<td>O—H</td>
<td>460</td>
</tr>
<tr>
<td>H—H</td>
<td>416</td>
</tr>
<tr>
<td>C—H</td>
<td>413</td>
</tr>
<tr>
<td>Noncovalent Bonds (Weaker)</td>
<td></td>
</tr>
<tr>
<td>Hydrogen bond</td>
<td>20</td>
</tr>
<tr>
<td>Ion–dipole interaction</td>
<td>20</td>
</tr>
<tr>
<td>Hydrophobic interaction</td>
<td>4–12</td>
</tr>
<tr>
<td>Van der Waals interactions</td>
<td>4</td>
</tr>
</tbody>
</table>

*Energy values are approximate and can vary slightly depending on conditions.
The Hydrogen Bond
H-bonding in H$_2$O

Each H$_2$O molecule is ________________________________
- two as ______________ (O) and two as ______________ (H).
The Hydrogen Bond

H-bonding in H₂O

Unique H-bonding in H₂O

Table 2.4

Comparison of Properties of Water, Ammonia, and Methane

<table>
<thead>
<tr>
<th>Substance</th>
<th>Molecular Weight</th>
<th>Melting Point (°C)</th>
<th>Boiling Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (H₂O)</td>
<td>18.02</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Ammonia (NH₃)</td>
<td>17.03</td>
<td>-77.7</td>
<td>-33.4</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>16.04</td>
<td>-182.5</td>
<td>-161.5</td>
</tr>
</tbody>
</table>
The Hydrogen Bond
The importance $\text{H}_2\text{O}$ of to life

Due to the polar nature of water, polar solutes

[Diagram showing hydrogen bonds between different functional groups and water]
The Hydrogen Bond
The importance \( \text{H}_2\text{O} \) of to life

Helps to stabilize the ________________________

H-bonding between ____________________ within a protein and between proteins

- DNA

H-bonding ____________________

Types of hydrogen bonding in proteins

- Interstrand
- Intrastrand

Hydrogen bonds between the strands of a DNA double helix

- Interstrand
Thermodynamics in Relation to Biochemistry

Thermodynamics is a branch of physics which deals with

Within a system (biological) processes ________________
___________________. Processes that ________________ are not favored

**Spontaneous**: - process (reaction) which occurs ________________
- ________________
- ________________
- does not mean ________________

**Nonspontaneous**: - requires input of __________________________
- ____________________
1\textsuperscript{st} law of thermodynamics: - matter (energy) can be neither __________________________
- can only be ______________________
“law of __________________________”

Process that releases energy (__________________):
hydrolysis of ATP

So, energy released from ATP hydrolysis __________________________
_________________________ (nonspontaneous) reactions.
Thermodynamics in Relation to Biochemistry

Free energy of a system: - A measurement of ________________
__________________________
- A way to measure the ________________
__________________________.

Gibbs free energy, ΔG: the work exchanged by ____________________

J. William Gibbs (1839 - 1903)
Yale University
Laid foundation of chemical thermodynamics and physical chemistry
Thermodynamics in Relation to Biochemistry

Values of $\Delta G$ in relation to spontaneity

$\Delta G < 0$ - process (reaction) is _______________
- exergonic - ____________________
- free energy of the ________________

$\Delta G = 0$ ________________

$\Delta G > 0$ process (reaction) is _______________
endergonic - ____________________
free energy of the ________________

Spontaneous process, metabolism of glucose:

$\text{glucose} + 6 \text{ O}_2 \rightarrow 6 \text{ CO}_2 + 6 \text{ H}_2\text{O}$ ________________

Nonspontaneous process, formation of ATP:

$\text{ADP} + \text{HPO}_4^- + \text{H}^+ \rightarrow \text{ATP} + \text{H}_2\text{O}$ ________________
Thermodynamics in Relation to Biochemistry
Order/Disorder

Entropy, $\Delta S$ - 2nd law of thermodynamics
- a measure of ______________
- a direct measure of the ___________________
- the higher the entropy the greater the disorder
- systems tend ___________________
- organisms are constantly trying to increase order, fight entropy

2nd law of thermodynamics: spontaneous processes occur in directions that _____________________________.

spontaneous hydrolysis of ATP
Consider: Glass of ice water:

Ice is very ordered, ______________

Will tend to become ______________ by ice melting, increasing entropy until ______________