Osmolality (Osm):
- Measurement of body water concentration

Osmolality:
- Total molality of solutes in solution
- Number of dissolved solute particles in one liter (1Kg) H₂O (solvent)
Need to determine if the molecules will **dissociate or distribute**

a. **Dissociate:** Ionic Bonds within molecules
   - Acids, bases, and salts (ions)
   - One molecule dissociates into “pieces”

**NaCl** dissociates into **Na⁺** AND **Cl⁻**
b. Distribute: **Covalent Bonds** within molecules
   (Organic molecules-sugar, protein, fat)

- Molecules distributed by the greater concentration water molecules
- One Molecule remains ONE molecule

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- **Molecular structure unaffected** by water

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**Osmolality:**

- Number of dissolved solute particles in one liter (1Kg) H₂O

\[
\text{Osmol} = \text{molality} \times \# \text{“wet solutes” (particles)}
\]

- \(1 \text{ mol glucose} = \text{Osmol glucose}\)

\[
\text{Will Glucose Dissociate or Distribute?}
\]

Glucose is Organic: with covalent bonds

\[
1 \text{ mole glucose} \times \frac{1 \text{ solute particle}}{1 \text{ L H}_2\text{O}} = 1 \text{ Osmol glucose}
\]
\[ 2 \text{ m glucose} = \frac{2 \text{ mole glucose}}{1 \text{ L H}_2\text{O}} \times 1 \text{ solute particle} \]

\[ = 2 \text{ Osmol glucose} \]

\[ 1 \text{ m NaCl} = \frac{1 \text{ mole NaCl}}{1 \text{ L H}_2\text{O}} \times 2 \text{ solute particles} \]

\[ = 2 \text{ Osmol NaCl} \]

Osmolality vs Molality

- **Molality** = \# mole of "dry" substance being added to a liter of water
- **Osmolality** = \# mole of "wet" substance added to a liter of water
Potassium Sulfate

\[ \text{K}_2\text{SO}_4 \rightleftharpoons 2\text{K}^+ + \text{SO}_4^{2-} \]

1 m K\textsubscript{2}SO\textsubscript{4} = 3 Osmol

0.5 m K\textsubscript{2}SO\textsubscript{4} = 1.5 Osmol

Will K\textsubscript{2}SO\textsubscript{4} Dissociate or Distribute?

Plasma Osmolality = 0.3 osmol 300 mOsmols

Solution Acidity : pH

Based on H\textsubscript{2}O ionization

\[ \text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^- \]

1/554 million H\textsubscript{2}O molecules ionizes
• pH = “Power of hydrogen concentration”
  * pH = –log [H+]

• H+ ion concentration in 1 liter H2O:
  = 10⁻⁷ mols H⁺ / liter or (gms/liter)
  = 0.0000001 H⁺ mols / liter or (gms/liter)

Neutral solution: Equal concentration of H⁺ & OH⁻

[H⁺] = 10⁻⁷ M (moles/liter) = 0.0000001 M
[OH⁻] = 10⁻⁷ M

* Ionization water = [H⁺][OH⁻] = 10⁻¹⁴

Acidic Solutions:

Greater concentration of H⁺ than pure water neutral

[H⁺] = 10⁻⁵

Does a solution of 10⁻⁵ have more or less H⁺ than water?

10⁻⁷
0.00001
0.000001

Acid Solution
- Hydrogen ions - H⁺

Hydroxide ions - OH⁻
Basic Solutions:

› Lower concentration of $H^+$ than pure water

› i.e: $[H^+] = 10^{-11}$

Does a solution of $10^{-11}$ have more or less $H^+$ than water?

$10^{-11} < 10^{-7}$

$0.0000000001 < 0.000001$

<table>
<thead>
<tr>
<th>Ion Concentration (gram equivalent per liter)</th>
<th>Type of Solution</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Acid Solution</td>
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<tr>
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<td>0.01</td>
<td>$H^+$</td>
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<tr>
<td>0.001</td>
<td>Basic (alkaline) Solution</td>
</tr>
<tr>
<td>0.0001</td>
<td>- Hydroxide ions -</td>
</tr>
<tr>
<td>0.00001</td>
<td>$OH^-$</td>
</tr>
</tbody>
</table>

pH Scale: $pH = -\log [H^+]$

$pH = -\log [10^{-7}] = -[-7] = 7$

<table>
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<tr>
<th>$pH$</th>
<th>Ion Concentration (gram equivalent per liter)</th>
<th>Type of Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0000001</td>
<td>0.0000001</td>
<td>Acid Solution</td>
</tr>
<tr>
<td>0.0001</td>
<td>0.0001</td>
<td>- Hydrogen ions -</td>
</tr>
<tr>
<td>0.01</td>
<td>0.01</td>
<td>$H^+$</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>Basic (alkaline) Solution</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>- Hydroxide ions -</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>$OH^-$</td>
</tr>
</tbody>
</table>
Acidic solutions: pH < 7
Basic solutions: pH > 7

Ionization of water produces: Relative ion concentrations

\[
[H^+][OH^-] = 10^{-14} \text{ molar}
\]

\[
[10^{-2}][10^{-2}] = 10^{-14} \text{ molar}
\]

ie:

\[
[10^{-5}][10^{-9}] = 10^{-14} \text{ molar}
\]

\[
[10^{-8}][10^{-6}] = 10^{-14} \text{ molar}
\]

If the concentration of either H^+ or OH^- is known, you can figure out the other

\[
[10^{-2}][10^{-x}] = 10^{-14} \text{ molar}
\]

\[
[10^{-x}][10^{-3}] = 10^{-14} \text{ molar}
\]

If the concentration of either H^+ or OH^- is known, you can figure out the pH

\[
[H^+][OH^-] = 10^{-14} \text{ molar}
\]

\[
[10^{-2}][10^{-x}] = 10^{-14} \text{ molar} = \text{pH 2}
\]

\[
[10^{-x}][10^{-3}] = 10^{-14} \text{ molar} = \text{pH X}
\]

pH 11: Acidic or Basic

X = 11
Acid: Molecule releasing $H^+$ in solution

\[ \text{HCl} \rightarrow H^+ + Cl^- \]
\[ \text{H}_2\text{CO}_3 \rightarrow H^+ + \text{HCO}_3^- \]

⊕ “Proton Donor”

Base: Molecule decreasing $H^+$ in solution by combining with $OH^-$

\[ \text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^- \]
\[ \text{KOH} \rightarrow \text{K}^+ + \text{OH}^- \]

⊕ “Proton acceptor”

 BUFFER:

System of molecules & ions which: minimize changes in [H$^+$]

→ Stabilize pH

* ie. Blood pH (7.35 – 7.45): Buffered by:
  a. Bicarbonate ($\text{HCO}_3^-$)
  b. Carbonic Acid ($\text{H}_2\text{CO}_3$)

\[ \text{HCO}_3^- + H^+ \leftrightarrow \text{H}_2\text{CO}_3 \leftrightarrow \text{H}_2\text{O} + \text{CO}_2 \]

Changing solution acidity

\[ H^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

Breaks down into

Increase Acidity:
Add excess $H^+$ Binds Bicarbonate Forms Carbonic acid Exhale $CO_2$

Correction: formation of Carbonic Acid

→ Blood acidosis: increases formation of

\[ \text{H}_2\text{CO}_3 \text{ Carbonic Acid & then } \text{CO}_2 + \text{H}_2\text{O} \]

→ Blood alkalosis: increases formation of

\[ \text{HCO}_3^- \text{ Bicarbonate + } H^+ \]
Hypoventilation:

- Results in: **Acidosis**

Diabetic Acidosis: Kussmaul Breathing

**Organic Chemistry:**

- **Organic Molecules:**
  - Formed by *actions of living things*
  - Contain: Carbon "Backbone" formed from **Carbon & Hydrogen**
4 Main Categories:

1. **Proteins**: Cellular machinery & structure
2. **Lipids** (fats): Energy storage, membranes, & communication (~85% total body energy)
3. **Carbohydrates** (sugars): Quick usable energy (~5% total body energy)
4. **Nucleic Acids** (DNA & RNA): Genetic Material

• Organic Molecule Characteristics

1. Generally very large molecules: >100,000 Daltons
2. Needed in large quantities: gram amounts
   ~ Macromolecules
3. Formed from linking similar repeating units
   ⇢ Single unit: **MONOMER**:
   mono = one

› Result: **Polymer**: Poly = many

› Unique Polymer arrangements result in different polymers
4. Process of Formation: **DEHYDRATION SYNTHESIS**
   * Process links: **ALL** organic monomers
     - “De” – Remove
     - “Hydration” – Water
     - “Synthesis” – Assembly
   * Result:
     **Removal of WATER / “Condensation”**

5. Process of disassembly: **HYDROLYSIS**
   * Process disassembles: **ALL** organic macromolecules
     - Hydro – water
     - Lysis – split
   * Result: **Addition/ incorporation of water**
4 Organic Molecules:

1. **Carbohydrates:** “Quick energy”
   - Primary fuel for CNS, blood cells, muscle (intense exercise)
   - Recommended: 45 – 65% of energy in diet
   - Carbo = Carbon ; Hydrate = H₂O
     \[ C_{n}(H_{2}O)_{n} \]
     \[ \text{Glucose} = C_{6}H_{12}O_{6} \]

- **Monomer:** Monosaccharide
  - *mono* = “one”
  - *saccharide* = “sugar”

  - Ring: *Carbon, Oxygen & Hydrogen*
  - “Simple Sugars”

- **Dehydration Synthesis:**
  - Forms: GLYCOSIDIC BONDS
  - Monosaccharide + Monosaccharide → Disaccharide
  - Disaccharide + H₂O
A. **Disaccharide**: 2 linked monosaccharides

B. **Oligosaccharide**: 3 – 10 monosaccharides

- Maltose
- Sucrose
- Lactose

C. **Polysaccharide**: 100’s to 1,000’s monosaccharides

*Complex Carbohydrates*

- Amylose
- Amylopectin
- Starch
- Glycogen
- Cellulose (fiber)