### Chapter 3

**Water and Life**

<table>
<thead>
<tr>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Water</td>
</tr>
<tr>
<td>A. Properties of water</td>
</tr>
<tr>
<td>II. Acids and Bases</td>
</tr>
</tbody>
</table>

---

**Water – The Life Giving Molecule**

- Why are we so interested in finding evidence of water on Mars?
- What would it mean if we did not find evidence of water? Or if we find evidence? Does it matter what form the water is?
- Life exists here because water is abundant

**Water’s Abundance**

- 71% of Earth’s surface is water
- 97.5% of the water is salt water
- Freshwater only accounts for 2.5% of water
- Only 0.53% is available to us to drink (rivers, lakes, ground water)
- 66% of the human body is water by weight
- 70-95% of a cell’s weight is water

---

**Water**

- Water is:
  - Polar
  - Forms hydrogen bonds
  - Exists in three states

---

**Outline**

*Note: Diagrams are not transcribed into plain text.*
**Polarity**

- The oxygen side of water is slightly negative and the hydrogen sides are slightly positive

**Exists in Three Forms**

- Water exists in three forms
  1. Solid - Ice
  2. Liquid
  3. Vapor

**Properties of Water**

1. Due to the hydrogen bonding, water has cohesion (the water molecules cling together)
   a) Important in blood flow through capillaries
   b) Pulls water up plants from roots to the leaves
Cohesion

- Cohesion is the capacity to resist breaking under tension
- Hydrogen-bonds create surface tension
- At the surface of water, where water meets air, the water molecules are being pulled down with a much greater force than they are being pulled up towards the air

Cohesion vs Adhesion

What is the difference between cohesion and adhesion?

Cohesion of Water Molecules

- Collectively, hydrogen bonds hold water molecules together, a phenomenon called cohesion
- Cohesion helps the transport of water against gravity in plants
- Adhesion is an attraction between different substances, for example, between water and plant cell walls
Water Transport in Trees

- Surface tension is a measure of how hard it is to break the surface of a liquid
- Surface tension is related to cohesion

Properties of Water

2. Due to hydrogen bonds, water has a high specific heat, this means the temperature of water rises and falls slowly
   a) preventing sudden changes in temperature, keeps living organisms at a stable temperature

Specific Heat

- What is the definition of Specific Heat?

Water’s High Specific Heat

- The specific heat of a substance is the amount of heat that must be absorbed or lost for 1 g of that substance to change its temperature by 1°C
- The specific heat of water is 1 cal/g/°C
- Water resists changing its temperature because of its high specific heat

Properties of Water

3. Due to hydrogen bonds, water has a high heat of vaporization - Water does not turn to a gas vapor until it gets really hot
   a) Important in cooling body through sweating
Heat of Vaporization

- What is the definition of Heat of Vaporization?

Evaporative Cooling

- Evaporation is transformation of a substance from liquid to gas
- **Heat of vaporization** is the heat a liquid must absorb for 1 g to be converted to gas
- As a liquid evaporates, its remaining surface cools, a process called evaporative cooling
- Evaporative cooling of water helps stabilize temperatures in organisms and bodies of water

Properties of Water

4. Due to the hydrogen bonding, ice has a lower density than water
   
   a) Lakes do not freeze allowing fish to survive the winter
   b) Polar ice caps are an important habitat

Properties of Water

5. Because water is polar it acts as a solvent for polar molecules, allows solutes to remain in solution
   
   a) Important in blood’s transport function
   b) Keeps molecules and ions in solution inside cells

Water as a solvent

- Like dissolves in like, so polar molecules dissolve in water
- Water is considered the best polar solvent
Hydrophobic molecules are ________ by water

1. Attracted
2. Repelled

What type of bond between water molecules creates surface tension that gives water cohesion?

1. Ionic
2. Covalent
3. Hydrogen

Acids and Bases

- We are already familiar with acids and bases
- Common acids:
  - Lemon juice
  - Sodas
  - Vinegar
- Common bases:
  - Ammonia
  - Many household cleaners
  - Bleach

Acids and Bases

- Acids – Substances that donates hydrogen ions (proton) when in solution
  - $\text{HCl} \leftrightarrow \text{H}^+ + \text{Cl}^-$
- Bases – Substances that accept hydrogen ions when in solution
  - $\text{NaOH} \leftrightarrow \text{Na}^+ + \text{OH}^-$
  - $\text{H}^+ + \text{OH}^- \leftrightarrow \text{H}_2\text{O}$
- In solution:
  - $\text{H}^+ + \text{Cl}^- + \text{Na}^+ + \text{OH}^- \leftrightarrow \text{H}_2\text{O} + \text{NaCl}$
The strength of acids and bases is measured using the pH scale.

- \[ \text{pH} = -\log_{10}[\text{H}^+] \]
- \([\text{H}^+] = \text{conc in moles per liter}\)

It is an inverse relationship:
- Higher the pH the lower the concentration of H^+
- Logarithmic:
  - Each point increase in pH represents a ten-fold decrease in H^+ concentration.

Scale from 0 – 14
- 0 is the most acidic
- 14 is the most basic
- 7 is neutral (pure water)
The higher the pH a solution has, the higher the H+ concentration

1. True
2. False

Is a pH of 8 acidic or basic?

1. Acidic
2. Basic

Biological Fluids

- Blood – pH 7.35 Changes in pH of ± 0.1 can damage cells, pH of 7.8 can be lethal
- Biological fluids have buffers to keep the pH stable.
- Most biological fluids are between 6 – 8
- Stomach fluid – pH of under 2

Buffers

- Buffers resist changes in pH when an acid or base is added.
- For example when CO₂ enters the blood it combines with H₂O to form carbonic acid (H₂CO₃). This weak acid dissociates to form H+ and bicarbonate ion (HCO₃⁻)

![Fig. 2.16](image-url)
Acid Precipitation

- Read the section on page 55-56
- The two main sources of acid rain are H₂SO₄ and HNO₃
- Most of H₂SO₄ pollution comes from electric power plants
- Most of HNO₃ pollution comes from cars, buses etc

Effects of Acid Rain

- Acid rain acidifies lakes and streams
- More acidic water leaches more heavy metals from the soil than normal water.
- Declining frog and fish populations are due more to increased metal concentrations in the water than due to the acidic water itself

Ocean Acidification

- What human activities contribute to ocean acidification?
- What effect does this have on the oceans?

Soil Sensitivity to Acid Rain


Important Concepts

- Reading for next lecture: Chapter 4
- Know the vocabulary for this lecture/chapter
- What are the properties of water and why are these properties important to biology and life
- Be able to describe acids, bases, the pH scale and buffers
- What are the causes and effects of acid precipitation